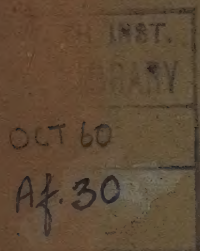


53ème Année

44^e Volume



BULLETIN
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**STUDIES ON THE HONEY PRODUCTION
OF CERTAIN RACES OF THE HONEYBEE,
APIS MELLIFICA L.**

[*Hymenoptera: Apidae*]

(with 6 Text-Figures)

by M. H. HASSANEIN, PH.D. (London)

and M. A. EL-BANBY, PH.D. (Ain Shams),

Plant Protection Department, Faculty of Agriculture, Ain Shams University.

INTRODUCTION

The selection of the best race in honey production is an important problem facing the beekeepers. Apiarists in some countries give each race a sufficient trial to become accustomed to its special characteristics and then choose the most satisfactory race.

The present investigations were carried out to choose the best race in honey production and to calculate the amount of honey stored by the individual bee of each race during her life.

ECKERT (1947) stated that the German, Cyprian, Italian, Caucasian and Carniolan races of honey bees were all imported in the U.S. America, but the Italian is now the most popular, then the Caucasian and the Carniolan is the third strain. He added that the Italian bees, which winter well, are prolific, industrious and usually gentle when purebred. First crosses between the Italian and the Caucasian, or the Italian and Carniolan races or the reciprocal crosses, are generally as desirable as the original strains, but second and third crosses are usually undesirable.

The strains of bees used in the present studies were the Carniolan, Caucasian and Italian, which are considered as standard races all over the world.

REVIEW OF LITERATURE

The annual honey crop of a colony of honey bees is dependent upon a considerable number of factors, part dealing with the activities of the bees and part resulting from the various external factors influencing the secretion of nectar by the honey plants of the locality.

TSCHUDIN (1921) stated that the honey yield increased as the elevation increased. He studied colonies both at sea level and at different elevation in the French Pyrenees, and found that colonies located between four and five thousand feet above sea level yield almost three times as much honey as those located between sea level and thousand feet.

FARRAR (1944) stated that the population of the small colony increases more rapidly because proportionally more bees engage in brood rearing, whereas the large colony produces more honey because a large percentage of its bees are available for field work. He added that colonies with maximum population produce not only more honey per colony but also more honey per bee than smaller colonies. One full strength colony containing sixty thousands bees normally produces 50% more honey during two weeks honey flow, than four small colonies each with fifteen thousand bees.

MOFFETT and MARKER (1953) found that over 58% of the nectar was stored on days when the maximum daily temperatures were between 85 and 94°F., 10% of the nectar was stored on days when the maximum temperature was 100°F. or over, but only 33% of the honey crop was stored when the maximum daily temperature was under 80°F. He found also that the best maximum daily temperatures for a good daily nectar flow during June and July were between 90-94°F., but in August a maximum daily temperature between 85 and 89°F. was best for daily nectar flow. The best daily range of temperatures for a good June nectar flow was between 21 and 25°C., while a daily range of 31 to 35°C. was most favourable for a good daily nectar flow in August. Extremely higher or extremely lower ranges in daily temperatures were not favourable for a good daily nectar flow.

WAFA (1954) found that the average changes in colony weight varies from 3.4 ounces per day in September to 13.5 ounces per day during July, at Rothamsted.

A highly significant correlation, 0.81, exists between the degree of activity undertaken by the bees and changes in colony weight. The net yearly changes in colony weight follow the weather fluctuations and no periodical trends had been observed.

EL NAHAL (1954) stated that the increase in weight of bee colonies during clover honey flow was more than the increase during the cotton honeyflow in Giza region. It was concluded from his results that the colonies averaged 15.5 kilograms of clover honey, and 5.17 kgm of cotton honey, in the year 1947 they increased to 19.57 kgm in the clover blooming season and 9.58 kgm in the cotton blooming season.

METHOD

During the blooming seasons of clover and cotton, in the year 1957, all the colonies of the three races, Caucasians, Carniolans and Italians, were weighed weekly before the bees fly in the morning to the field. A fully automatic scale balance sensitive to 25 grams, was used. The weights were carried out till the end of nectar season. The experiments were carried out immediately after the disappearance of the bee eaters on the 9th. May and continued till extracting the honey on the 10th. of August of the same year. Although the cotton flowers lasted till the middle of August, yet the colony weights decreased after the 21st of July by the effect of the applications of insecticides for the control of cotton pests during this period.

During these two flowering seasons, the colonies were not manipulated for the purpose of changing their storing capacity, except that enough room was given by the addition of ample combs or supers. The records are therefore largely a presentation of what bees obtain without the interference of the beekeeper. In order to obtain the net gains and net losses in the weight of each, everything that was added or taken from it was first weighed.

The blooms of citrus trees were not considered as sources of surplus, because the nectar yield during this period was scarcely sufficient for the need of brood rearing, that increased gradually at this time. At the end of the citrus blooming season the colonies were usually fed to maintain their brood rearing rates.

RESULTS AND CONCLUSIONS

It was found by statistical analysis of the results that there were highly significant differences between the races in honey production. Figure 1 shows that the colony weights increase gradually during the first four weeks of the clover blooming season, then it drops in the fifth week. The increase in weight of the Carniolan colonies exceeded the increase of the Caucasian and Italian colonies. The increase of the Caucasian colonies was the least during the first week of the clover blooming season. During the second week, the increase of the Carniolan colonies was less than that of the Italians, but more than that of the Caucasian colonies. During third, fourth and fifth weeks, the increase of the Italian colonies was larger, than that of the Caucasians and lastly that of the Carniolans.

It is obviously clear that the Carniolan colonies increased more speedily in weight in the first week than the colonies of the other races, because the Carniolan colonies produced more workers than the colonies of the other races before the beginning of the honeyflow.

The average weight of the Caucasian colonies increased 1.137 kgm in the first week, 2.219 kgm in the second week, 3.018 kgm in the third week, 3.750 kgm in the fourth week and 1.694 kgm in the fifth week.

The average weight of the Italian colonies increased 1.362 kgm in the first week, 2.680 kgm in the second week, 3.595 kgm in the third week, 5.112 kgm in the fourth week, and 2.735 kgm in the fifth week.

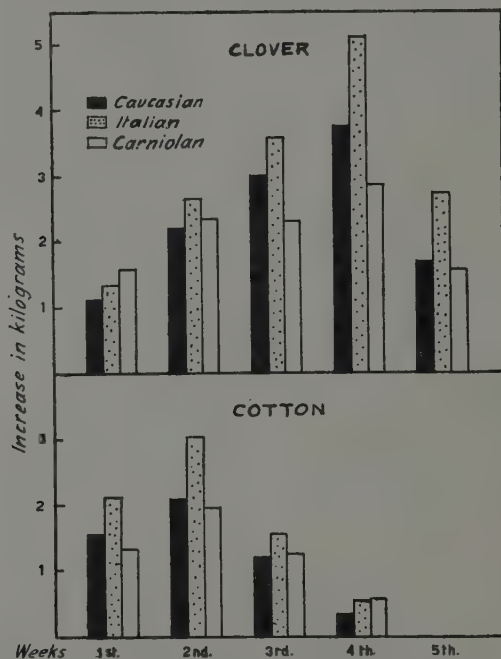


FIG. 1: Average increase in weight of the colonies during each week of clover and cotton blooming seasons.

The average weight of the Carniolan colonies increased 1.617 kgm in the first week, 2.361 kgm in the second week, 2.347 kgm in the third week, 2.870 kgm in the fourth week and 1.575 kgm in the fifth week.

It is clearly shown that the increase in the colony weight, during the blooming season of cotton, reached its maximal height in the second week, then it declined gradually till the end of nectar yield. The colonies weight decreased from the fifth week due to the applications of insecticides for the control of cotton pests, and consequently killing foraging bees. No foragers returned to their hives during this period and the stored honey was consumed by the house bees.

The average weight of the Caucasian colony increased 1.596 kgm in the first week of the blooming season of cotton, 2.186 kgm in the second week, 1.118 kgm in the third week and 321 gms in the fourth week.

The average weight of the Italian colony increased by 2.133 kgm in the first week, 3.050 kgms in the second week, 1.558 kgm in the third week, and 558 gms in the fourth week.

The average weight of the Carniolan colony increased by 1.335 kgm in the first week, 1.955 kgm in the second week, 1.270 kgm in the third week, and 575 gms in the fourth week.

Figure 2 shows that the total increase in weight, during the clover blooming season averaged 11.819 kgm in the Caucasian colonies, 15.485 kgm in the Italian colonies and 10.768 kgm in the Carniolan colonies. During the four weeks of nectar yield from cotton flowers, they averaged 5.221, 7.300 and 5.135 kgm, respectively.

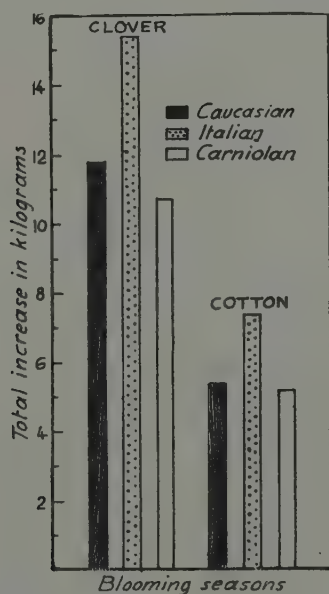


FIG. 2: Average increase in weight of the colonies during the blooming seasons of clover and cotton.

It was noticed that the colonies in the present investigations did not store honey from citrus blooms, in the district. Thus, all the efforts spent by the colony during the year was devoted to gain the maximal yield of clover and cotton honeys.

It is well known that the workers reared all over the year indirectly manipulate the honey production of the two seasons together. The colonies rear worker brood during the year to increase their population and maintain their strength during the season of honeyflow. As the total honey crop of a colony under certain external

conditions depends upon its population and the activity of its workers, it was decided to find out the regression coefficients between the total increase in the colony weight and the total number of workers reared throughout the year to give an accurate account on the mean value of the individual of Caucasian bee reared during the year, which caused an average increase in colony weight, during the two blooming seasons, of 380.39 mgs, and the mean value of the individual Carniolan bee which caused an average of 262.59 mgs and the individual Italian bee whose average was 128 mgs.

It is concluded from Figure 3 that for yielding equal amounts of honey the Italian colonies need the greatest number of workers, while the Caucasian need the

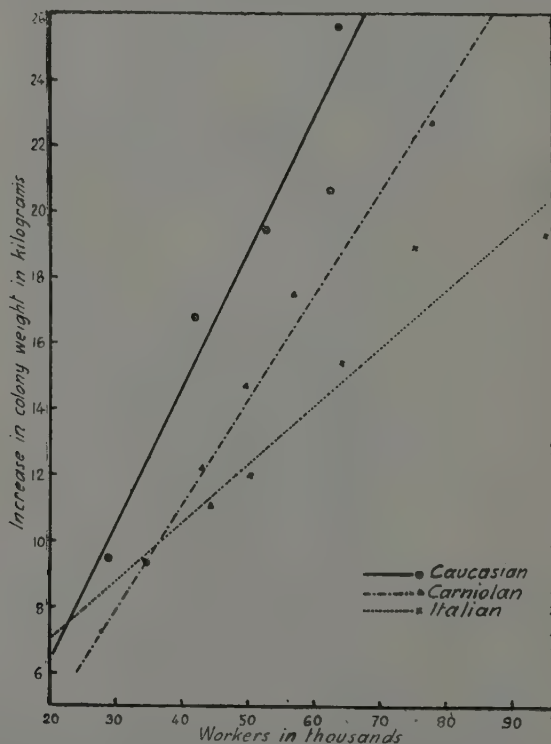


FIG. 3: Scatter diagram and regression lines between the number of workers reared in spring and summer and the total increase in colony weight.

least number. Thus, for yielding 20 kgms of honey during the two blooming seasons, the Caucasian colony can depend on rearing only 67,000 workers throughout the

year, the Carniolan must rear 90,000 workers, while the Italian colony should rear 121,000 workers under the local conditions of the experimental district. The regression lines of the three races are overlapped in small colonies, thus when rearing few workers the Italian colony may exceed the Caucasian and Carniolan colonies in honey production by rearing equal number of workers.

It is well known that there is a relationship between the colony's population during the spring and summer period and its honey production. Beekeepers usually feed their colonies at the end of the winter to stimulate brood

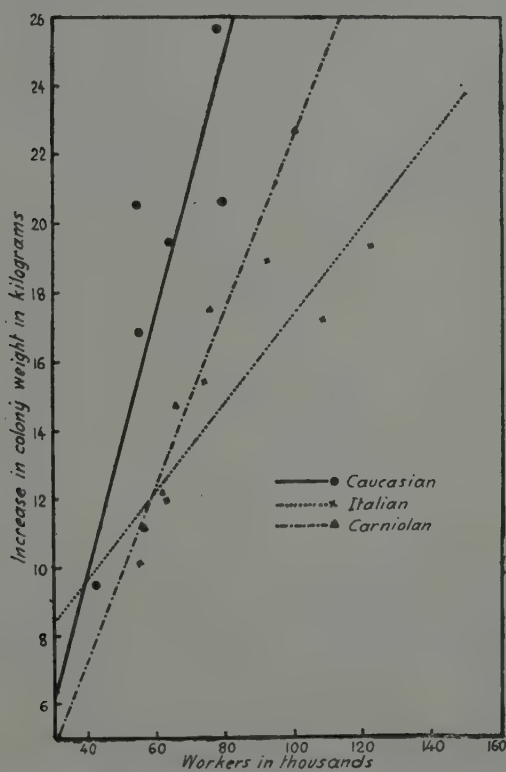


FIG. 4: Scatter diagram and regression lines between the number of workers reared throughout the year and the total increase in colony weight.

rearing and increase their population as early as possible, before the main honey-flows take place. It appears then that the regression coefficients between the total increase in colony weight and the amount of worker brood reared from the beginning of the spring till the end of cotton honey flow, give also an accurate value for

the individual bees reared during this period. It was found that the individual Caucasian worker reared in the spring and summer period averaged 417.36 mgs of increase in colony weight, the individual Carniolan worker averaged 319.75 mgs, and the individual Italian worker averaged 174.2 mgs.

It was decided in the present investigations to compare the values of the bees of each race separately, during the two blooming seasons. These values could be calculated from the regression coefficients between the honey production of each season and the colony's population during the honeyflow. It was too difficult to

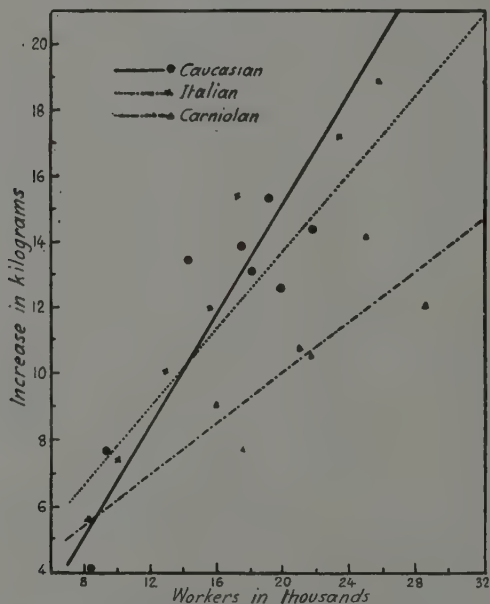


FIG. 5: Scatter diagram and regression lines between the increase in weights of the colonies and the amount of workers contributing in honey production during the blooming season of clover.

recognise the accurate number of workers which actually took part in honey production during each of the two flowering seasons. It was quite sufficient to find out the regression coefficients of the three races, between the colony's honey production during each season and the total number of workers reared during a certain limited time which were considered to spend all their foraging life in gathering honey of the same season. The regression coefficients of the three races could be compared with each other to determine the best worker from the three races during each season.

Figure 4 shows that for the yield of 15 kgm, for example, of clover honey, the Caucasian colony must rear 19,800 workers, from the 23rd. of April till the

29th. of May under the conditions of the experiments, the Italian colony must rear 22.000 workers during this period and the Carniolan colony should rear 32.600 workers.

Figure 5 demonstrates that the Caucasian worker, in strong colonies during the blooming season of cotton, is more prolific than the others, while the Italian and Carniolan workers may exceed her in small colonies. It is shown that for yielding 10 kgms of cotton honey 19.200 Caucasian workers are needed to be reared from the 10th. of June to the 4th. of July, while 23.800 Carniolan workers or 25.000 Italian workers are necessary to be reared during this period.

It is well known that brood rearing consumes great amounts of pollen and honey stored in the hive. It can be clearly noticed to what extent the individual Caucasian bee can produce more honey during the main honeyflows with the least consumption of food reserves. It is clearly observed that for gaining equal amounts of honey from the colonies of the three races, it is necessary for the Italian colony to rear the greatest amount of brood, the Carniolan colony can gain the same honey crop by a less number of workers and the Caucasian colony needs the least amount of workers to produce a similar yield.

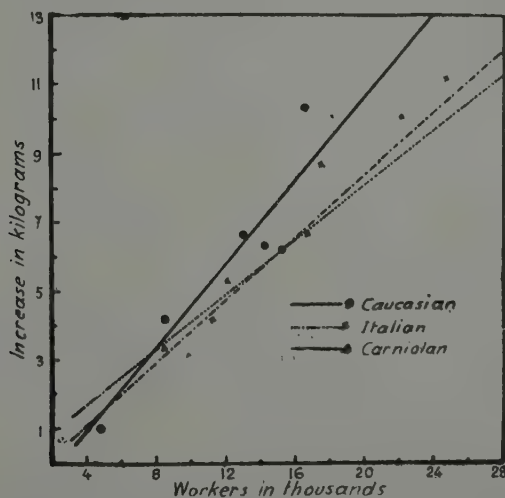


FIG. 6: Scatter diagram and regression lines between the increase in weights of the colonies and the amount of workers contributing in honey production during the blooming season of cotton.

The high produce in weight noticed in the Italian colonies, during the two honeyflows, is obviously related to their high brood rearing rates.

The honey extracted from the Italian colonies is relatively less than that extracted from the Caucasian and Carniolan colonies, because the brood of the

first race occupied the middle areas of many combs. The numerous workers reared by Italian colonies also need much of the stored honey to be consumed at dearth.

It is concluded from the above mentioned results that the best race or hybrid is that which produces the more numerous and active workers. It may be assumed that to breed such hybrid, Italian queenbees, which are more prolific than the other queens, should be mated with drones of races whose workers are more industrious such as the Caucasians and Carniolans. These assumptions may be verified by comparing the hybrids and the reciprocal hybrids of these three races, in different regions.

SUMMARY

The results in the present investigations show that the colony weights increase gradually during the first four weeks of clover blooming season and that it drops in the fifth week.

The total increase in weight during the clover blooming season, averaged 11.820 kgm in the Caucasian colonies, 15.480 kgm in the Italian colonies and 10.770 kgm in the Carniolan colonies.

The increase in weight of the colonies, during the blooming season of cotton, reached its maximal height in the second week, then it decreased gradually, till the end of nectar income.

The total increase in weight, during the blooming season of cotton averaged 5.220 kgm in the Caucasian colonies, 7.3 kgm in the Italian colonies and 5.130 kgms in the Carniolan colonies.

It was clearly demonstrated by calculating the regression coefficients between the numbers of workers reared by the colonies of each race and the increase in their weights, during the two main honeyflows, that the individual Caucasian bee is more beneficial to its colony, than the individual Carniolan bee and that the individual Italian bee is the least industrious worker.

The high increase in weight noticed in the Italian colonies during the two honeyflows, is obviously related to their high brood rearing rates. However, the honey extracted from the Italian colonies is relatively less than that extracted from Caucasian or Carniolan colonies, because the brood of the first race occupied the middle areas of many combs.

It is clearly shown from the above mentioned results, that the best race is that which produces the more numerous and active workers. It may be assumed that to breed the most prolific hybrid, Italian queens, which are more prolific than the other queens should be mated with drones of races whose workers are more industrious in honey production as the Caucasian and Carniolan.

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**STUDIES ON THE BROOD REARING ACTIVITY
OF CERTAIN RACES OF THE HONEYBEE,
APIS MELLIFICA L.**

[*Hymenoptera: Apidae*]

(with 3 Text-Figures)

by M. H. HASSANEIN, PH.D. (London)

and M. A. EL-BANBY, PH.D. (Ain Shams),

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INTRODUCTION

Studies were carried out to investigate the amounts of workers reared in the colonies of the Caucasian, Italian, and Carniolan honeybee races, the investigation of brood rearing activity in the different races to differentiate between races as far as the important factor concerning honey production is concerned. It is well known that the most populous colony produces not only the biggest honey yield per colony but also the maximum honey per bee.

Brood rearing is the basis of colony development and the maintenance of maximum population during the flow. It is dependent upon the queens capacity to lay eggs, the supporting populations ability to maintain favourable temperature and feed the brood, reserves of pollen and honey, and proper space for the expansion of the brood nest.

The tendency to swarming and the drone production, have also great effects on the total honey yield of the colonies. The drone brood cells, the queen cells and the cell cups were also counted in the present observations to study the swarming instinct in the colonies of the three honeybee races.

REVIEW OF LITERATURE

NOLAN (1922) found that the queen of a colony on which he had continued observations for two consecutive seasons, had laid an average of about 905 eggs

daily for a period of 224 days in 1921 and an average of 895 eggs daily for 238 days in 1922. He concluded that there was direct relation between nectar flow and brood rearing activity.

MERRIL (1922) indicated that colonies reduced their brood rearing during nectar flows, and that in colonies, well supplied with stores, the biggest peak of brood rearing actually occurred during the last week of May, when bad weather hindered foraging. This late increase in brood rearing during heavy nectar flow may be related to insufficient empty combs, which causes the bees to block their brood nest with nectar.

MILUM (1930) found that flights in the earlier part of the winter did not stimulate the colony to brood rearing, yet after a period of quiescence, flights in late February, March and April usually stimulated colonies to begin brood rearing regardless of whether pollen was carried in by the bees or not. However, brood rearing might not be continuous from then on through the spring period, but was dependent upon the supply of pollen and honey in the hive and the ability of the bees to take further flights to gather supplies of nectar, pollen and water which are essential.

MORLAND (1930) reported that all factors leading to the stimulation of nurse bees without sufficient larvae to feed, have great influence on formation of queen cells in preparation for swarming. The advent of honeyflow, beginning just before reaching the swarming point, may stimulate colonies to neglect swarming. In this condition the house bees are promoted to foragers, the nurse bees divert their energies to work in supers away from the brood nest in storing and ripening the honey and providing wax for cells and cappings to contain it. Colonies headed by young queens are apparently less liable to swarm than those that have old ones, because young queens lay more eggs in the autumn of the previous season, which make the colonies winter with younger bees. In the new year the young queen starts earlier and increases the brood nest at a steady rate, being less liable to be put off by conditions which would cause a check in the oviposition of an older queen.

FARRAR (1934) overwintered eight colonies, dissimilar only in respect of their pollen reserves. Between October and mid-April, four colonies without pollen reserves, reared no new bees, their populations dropped 55-88% and they ate 21-35 lbs. stores, two colonies with 160-170 sq. in reserve pollen reduced their population 40-51% and consumed 38-47 lbs. stores, two colonies provided with 615-626 sq. in reserve pollen contained only 5-8% fewer bees in mid-April having eaten 42-56 lbs. stores.

BODENHEIMER and NEYRA (1937), when studying the biology of the honey-bee in Palestine, found that the total egg production was (220.145) in single walled hive, as against (163800) eggs in the double walled hive. This difference was conditioned mainly by swarming which occurred in the double walled hive, and which caused an interruption of oviposition of about 38 days duration. The ten days

average of the number of eggs laid for the four weeks of most intensive egg-laying during the annual cycle, in Palestine (end of February and March), fluctuated between 1000 and 1300. Although the absolute daily maximum oviposition rate was regarded as quite normal, yet the total annual sum (220,000) eggs per hive was considered to be exceptionally high compared with that of similar hives in Europe or America, where 120,000-150,000 eggs per hive are regarded as a very good production.

TODD and BISHOP (1941) found that the trend of brood rearing in California was parallel to pollen income, and that the spring time egg-laying peak coincided with a peak of pollen collection in summer larger quantities of pollen seemed to produce less effect than smaller quantities had achieved in spring.

FARRAR (1944) indicated that colony populations are balanced by the colony's capacity for brood rearing, the time required to develop brood, and the length of life of the adult bees. He added that the longevity is influenced greatly by the intensity of brood rearing. The amount of brood reared is influenced by the queen's egg-laying capacity, the colony population, the supply of both pollen and honey, and the available comb space and its position.

RIBBANDS (1950) reported that autumn feeding with concentrated (66 2/3 by weight) sugar syrup not only produced the maximum quantity of stores but also produced a significant increase in the amount of brood rearing, feeding with a similar weight of sugar in dilute (38% by weight) syrup produced no visible increase in brood rearing.

CRANE (1950) stated that spring time feeding experiments which revealed a significant increase in brood rearing when dilute syrup was supplied to small colonies, but a smaller or nonexistent increase when the same syrup was fed to large colonies.

HASSANEIN (1953) found that colonies infected with *Nosema apis* rear less brood during a given period of time, than do colonies of healthy bees.

METHODS

Purely mated queen bees were imported during June and July of the year 1955. Italian queens were imported from Italy, Carniolan queens from Yugoslavia and Caucasian queens from Denmark. They were introduced to nuclei of hybrid bees, and combs of sealed brood were added gradually to the new colonies to increase their populations. In February 1956, the colonies of the three pure races which were in equal density, and whose workers were covering five combs, were selected for brood rearing experiments. These experiments were started by 12 Caucasian colonies, 10 Italian colonies and 10 Carniolan colonies.

The experimental colonies were placed under observation also during the seasons of activity in the years 1956 and 1957, and during the intervening period

of dearth. They were used during this period without any stimulation of brood-rearing, only the normal feeding, during winter, which was offered equally to the different colonies.

The amounts of sealed worker and drone brood, present in the colony, were estimated separately, every twelve days, by measuring their area in square inches. The queen cells and cell cups were counted and destroyed at each observation, to study and prevent the swarming instinct.

Some colonies lost their queens, while these experiments were carried out and they were requeened with virgin queens.

The results of the colonies whose pure queens survived until the end of the blooming seasons of cotton in 1957, were only analysed in the present investigations; those colonies whose queens died at different periods of the experiments were excluded.

RESULTS

The amounts of sealed worker brood cells, in the colonies of the three races are clearly illustrated in Figure 1. It includes the curves of the average of worker brood, found at each observation in the colonies of the three races.

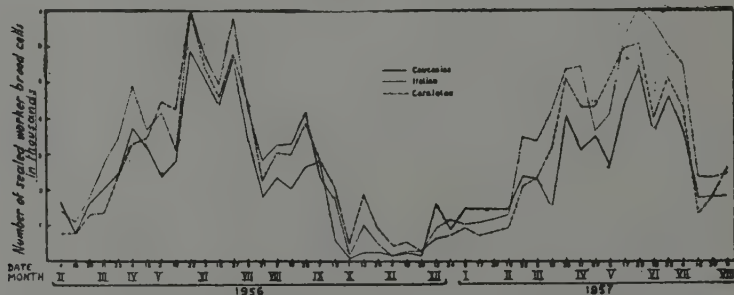


FIG. 1: Number of sealed worker brood cells found in the colonies of the three races.

The results of worker brood reared during the flowering seasons of 1956 and 1957 were calculated and the daily brood rearing rates during each season were reckoned by dividing the total amounts on the duration of each season. The total amounts and daily brood rearing rates of the colonies, during the flowering seasons of citrus, clover and cotton of the two years, and the period of dearth intervening between the citrus and clover blooming seasons.

The daily brood rearing rates during these seasons were analysed. There were highly significant differences between races and also between seasons as regards the daily brood rearing rates in the colonies.

As the inter-actions between races, seasons and years were insignificant it was preferred to carry out individual comparisons between the three races as regards the daily brood rearing rates. The differences between the daily brood rearing rates in the Caucasian and in each of the Italian and Carniolan colonies were significant.

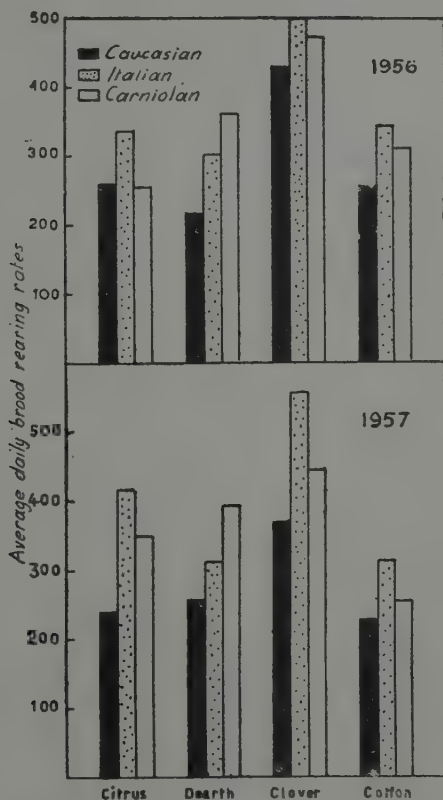


FIG. 2: The average daily brood rearing rates in the colonies during the flowering seasons of 1956 and 1957.

Figure 2 shows the average daily brood rearing rates in the colonies of the three races during the flowering seasons and the period of dearth intervening between them, in the years 1956 and 1957.

The total amounts of worker brood reared in the colonies of the three races were recorded during three semi-yearly periods (each 180 days). The first period started in the spring of 1956 at the commencement of the season of activity on

the blooming ornamental plants and trees. It lasted till the end of cotton flowering of the same year. The second period began by the end of the cotton flowering period and continued till the last week of February 1957. The third period covered the flowering period of 1957 till the end of the cotton, blooming season on the 9th. of August 1957.

The average amounts of worker brood reared by the Caucasian colonies in the periods of spring and summer were 58.956 workers in the year 1956 and 46.731 workers in 1957. The mean amounts reared by the Italian colonies in the spring and summer seasons of the two years successively were 62.262 and 68.150. The amounts of brood reared by the Carniolan averaged 56.225 workers in the season of activity in 1956, and 57.825 in the active season of 1957.

The amounts of workers reared in the semi-yearly period intervening between the seasons of activity of the two years averaged 13.476 in the Caucasian colonies, 17.429 in the Italian colonies, and 18.254 in the Carniolan colonies.

As the inter-action between races and seasons was insignificant it was found more easier to carry out individual comparisons between the three races. There

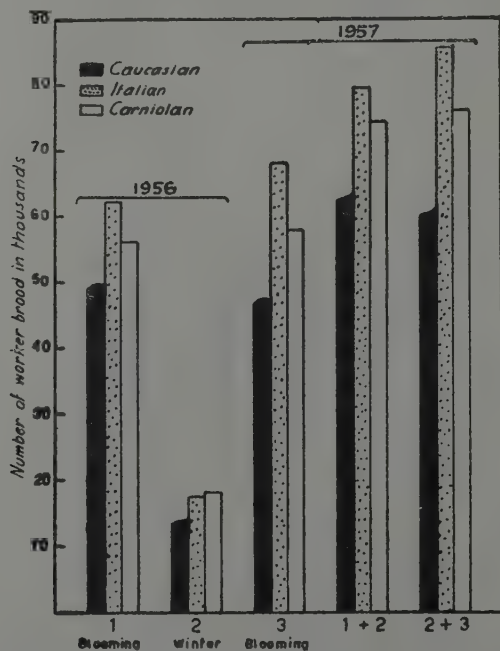


FIG 3: The average numbers of workers reared by the colonies of the three races in semi-yearly periods (blooming seasons of 1956 and 1957 and the intervening winter) and the total amounts reared in yearly periods.

were significant differences between the amounts of workers reared by the colonies of the Caucasian races and each of the Italian and Carniolan races.

Figure 3 shows the average amounts of worker brood reared by the colonies of the three races during the three semi-yearly periods, and during two yearly periods.

CONCLUSIONS

As the brood rearing activity depends largely upon the amount of nectar and pollen available to bees, it was necessary to record the approximate blooming of the more important plants in the district. The ornamental plants and trees began blooming gradually since the first of February and lasted till the end of the spring. The citrus flowering period began in the middle of March and ended in the third week of April. These blooms, however, were not considered as sources of surplus, especially when weather conditions were unfavourable. The importance of these early sources was that they stimulated the brood rearing activity before the commencement of the main honey flows of the year. A period of dearth followed the blooming season of citrus trees. The Egyptian clover bloomed before the first of May till the middle of June, but bees did not get great benefit from the early blooms of clover, because the bee-eaters (*Merops* spp.) were flying enormously since the last week of April till the middle of May 1956. In the year 1957, the numbers of bee-eaters were less and disappeared entirely after the first week of May. As the clover blooms dried off the cotton flowers opened gradually by the third week of June, and continued till the middle of August. In the middle of August, the bees, began gathering pollen from corn anthers, till the third week of September. From this time on till the appearance of the flowers of broad beans in the middle of December, scarcely flowers were found blooming in the field suitable for bee foraging.

Figure 1 shows that the amount of worker brood increased gradually since the middle of February, at the appearance of spring flowers. The Caucasian and Italian colonies decreased their brood rearing activities at the end of the citrus blooming seasons in the two years. The Carniolan colonies continued increasing their brood rearing activities during the period of dearth intervening between the blooming seasons of citrus and clover in 1956 and showed a slow decrease during this period in 1957. After the first week of May, the colonies increased their brood rearing capacity, at the blooming season of clover, until they reached their utmost in the third week of May. The colonies of the three races decreased their brood rearing activity by the dryness of the clover flowers, and began to recover their increase in the middle of June showing a somewhat lower peak in the fourth week of the same month. In the year 1957, the Italian colonies decreased their brood rearing activities very slowly after the peak found in clover season thus the second peak did not appear in this year. Although the blooming season of cotton lasted till the middle of August, yet brood rearing lines declined sharply after these peaks

until they were relatively low in the middle of July. The sharp decline seems to be due to the effect of the chemical insecticides used in pest control during this period. After the end of the cotton blooming season, the colonies showed a somewhat recovering in their brood rearing activity by the effect of pollen yield from corn anthers. With the approach of fall, the brood rearing activity fluctuated at a very low rate, but it did not cease entirely in winter, unless in few colonies, and for short periods.

A general view on this figure shows that the Caucasian colonies were rearing brood at a low rate all over the year. The Italian colonies exceeded the Carniolan in brood rearing during all the flowering seasons, but the case was reversed during dearth and winter periods.

Few drones were reared in spring by the colonies of the three races. Some colonies did not rear drone brood at all during the two years. Queen cells and cell cups were found in some colonies during the spring and summer in few numbers that their presence did not indicate swarming instinct.

The amount of worker brood reared in different flowering seasons, and during that period of dearth prior to the blooming season of clover which is the main honeyflow in Egypt, are more important than that brood reared during winter. As the blooming seasons of the different plants had different durations, thus it was necessary to find out the daily brood rearing rates to compare them with each other.

The average daily rates of brood reared by the colonies of the three races were higher in the clover blooming seasons than that reared in cotton seasons. The Caucasian and Italian colonies decreased their brood rearing rates in the period of dearth after the citrus blooming seasons, of the two years, while the Carniolans increased their daily brood rearing rates.

The Caucasian colonies reared the less brood during the four periods. The Italians exceeded the Carniolans during the blooming seasons of the two years and the case was reversed in the period of dearth.

The average daily rates of brood reared by the Italian colonies in 1956 and 1957 were, successively, 335 and 418 in the blooming seasons of citrus, 303 and 323 in the periods of dearth, 496 and 556 in the flowering seasons of clover, and 342 and 311 in the flowering seasons of cotton.

The average daily rates of brood reared by the Carniolan colonies in the two years were, respectively, 255 and 350 when citrus trees were in bloom, 364 and 395 in dearth, 473 and 446 when clover was blooming and 310 and 254 when cotton was flowering.

The average daily rates of brood reared by the Caucasian colonies in the two years were, successively 261 and 240 in the blooming seasons of citrus trees, 217 and 257 in the periods of dearth, 428 and 370 in the blooming seasons of clover, and 254 and 227 in the blooming seasons of cotton.

The period of activity since the beginning of spring till the end of the cotton flowering season covered about half a year (or 180 days). The period of dearth in autumn and winter lasted also half a year. The Caucasian colonies reared the least

amount of brood during each of the three semi-yearly periods. The Italian exceeded the Carniolans during the spring and summer period, while the Carniolans reared more brood in autumn and winter.

The average amounts of worker brood reared by the Caucasian colonies in the periods of spring and summer were 48,956 workers in 1956, and 46,731 workers in 1957. The average amounts reared by the Italian colonies in the spring and summer seasons of the two years were, successively, 62,262 and 68,150. The amounts of brood reared by the Carniolans averaged 56,225 workers in the season of activity in 1956, and 57,825 in the active season of 1957.

The amount of workers reared in the semi-yearly period intervening between the seasons of activity of the two years averaged 13,476 in the Caucasian colonies, 17,429 in the Italian colonies, and 18,254 in the Carniolan colonies.

The amount of workers reared since the beginning of spring till extracting the honey of the cotton season, is obviously more important in honey production.

It is possible to find out the total amount of brood reared by any colony during a whole year by adding the amount that it reared in winter to that reared in the following season of activity. The Caucasian colonies reared the least brood in these yearly periods, while the Italians exceeded the other races.

The amount of worker brood reared during a whole year covering the flowering period of 1956 and the following fall averaged 62,432 in the Caucasian colonies, 79,691 in the Italians and 74,479 in the Carniolans. The amount reared during the blooming season of 1957 and the previous fall averaged 60,207 workers in the Caucasian colonies, 85,579 in the Italians, and 76,079 in the Carniolans.

ACKNOWLEDGMENTS

The writers express their thanks and gratitude to Dr. A. GAWAD HASSAN, head of the Plant Protection Department, Faculty of Agriculture, Ain Shams University, for his keen interest, valuable suggestions and great help during the work.

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THREE NEW MEALYBUGS FROM EGYPT

[*Homoptera: Coccoidea-Pseudococcidae*]

(with 3 Text-Figures)

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This paper represents a part in the revision of the mealybugs of Egypt. Three new species are here introduced to family *Pseudococcidae*, one in the genus *Amonostherium* Morrison and Morrison, one in the genus *Phenacoccus* Cockerell, and one in the genus *Spinococcus* Kir. The phenacoccine mealybug has less than eighteen pairs of cerarii, i.e. not quite typical. However, making a separate genus out of this case would be considered unjustified splitting since other species, already known in this genus, are with reduced number of cerarii. For the first species, the definition of *Amonostherium* had to be slightly extended.

Gratitude is here due to the late Prof. G. F. FERRIS for helping in the drawings, and in making the decision about the species referred to *Phenacoccus*. For the third species, Dr. MORRISON has the credit of drawing my attention to the genus. *Spinococcus*. The Ministry of Agriculture, represented by the Plant Protection Department, offered all the facilities required for the present job.

Amonostherium arabicum, sp. nov.

ADULT FEMALE. — Body small, oval, about 1.9 (1.6-2.4) mm. long and 1.1 (1-1.4) mm. wide.

Cerarii present only on the anal lobes, each with two stout cerarian setae, slightly swollen at basal half, and about 4 associated trilocular disc pores. A stout auxiliary seta may be present in the cerarius.

Head: Antennae short, 6-jointed; measurements, in microns, about as follows: I, 25; II, 25; III, 36; IV, 12; V, 18; VI, 65. Eye bases about 12 microns high and 18 microns in diameter. Beak stout, about 60 microns in length and the same in width.

Thorax: Legs short and stout, with a minute tooth near the apex of the claw which may be indistinct when the claw is not turned at the right angle; measurements of posterior leg, in microns, about as follows: trochanter, 42×15 ; femur, 90×36 ; tibia, 84×24 ; tarsus, 54×15 ; claw, 30; tarsal digitules, 18; claw digitules, 30; translucent dots very few, about 24 microns long and 18 microns wide at atrium; posterior apodemes on posterior tibiae only. Anterior spiracular apodemes about 30 microns long and 21 microns wide at atrium; median portion in all apode mes less than half as wide as atrium.

Abdomen: Anal ring slightly oval, incomplete anteriorly, about 50 microns wide, removed from apex of abdomen by about half its width; anal ring setae about as long as the width of the anal ring. Cisanal and obanal setae short, each about 15 microns long. Apical setae, unfortunately missing from all specimens at hand. Circulus wanting.

Dermal structures: Ostioles prominent though small, every lip with about 2-4 trilocular disc pores and 1 or 2 setae, except the posterior lips of the abdominal pair which have the disc pores only.

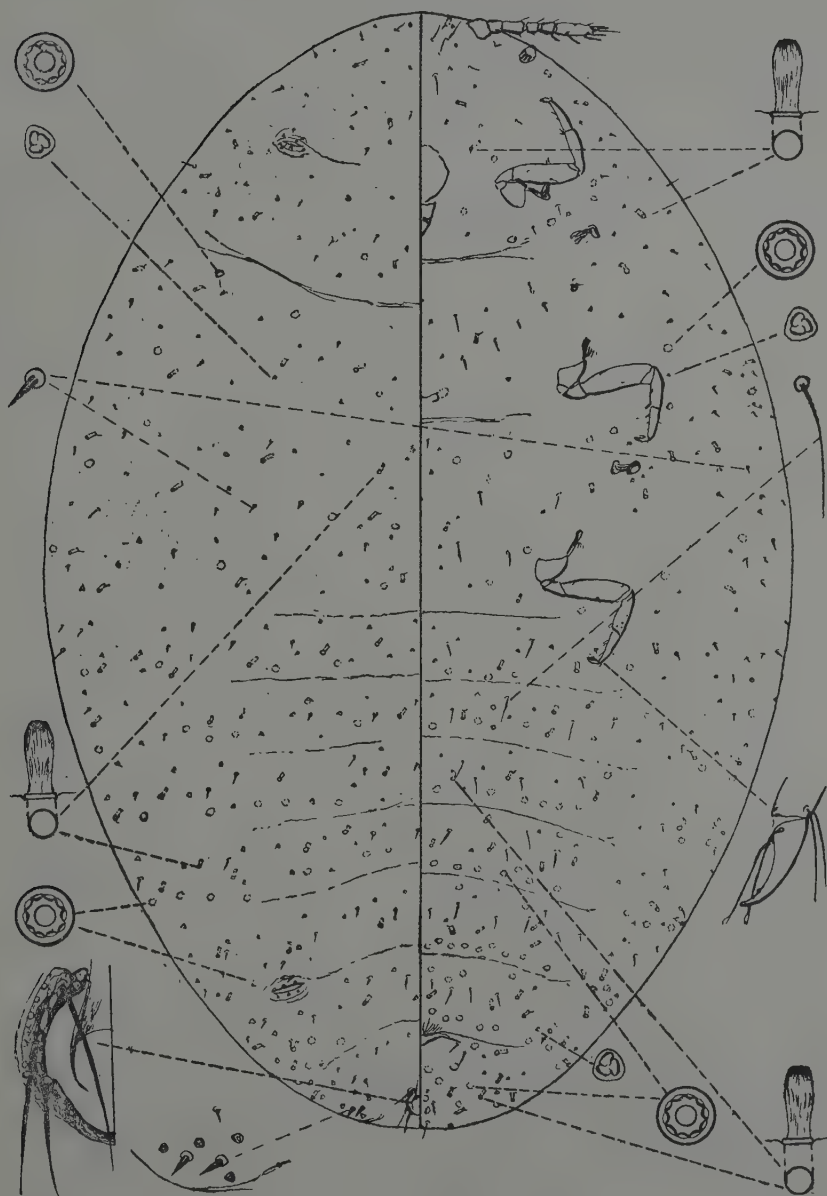
Dorsal body setae short and stout, slightly swollen at the basal half. Ventral body setae of two forms; those on marginal and submarginal areas are similar to dorsal setae while those on median and submedian areas are longer, fine and flagellate.

Trilocular disc pores sparsely distributed over both surfaces in the usual pattern, spaced about 5 to 12 times their diameter on dorsum, more widely spaced on venter.

Tubular ducts of the oral collar type only; about 9 microns long and 4 microns wide at opening; roughly distributed over both surfaces in simple transverse segmental rows. On dorsum, approximate numbers as follows; abdominal segments IX, 3; VIII, 10; VII, 8; VI, 8; V, 7; IV, 5; III, 7; II, 5; metathorax, 7; mesothorax 10; prothorax, 8; head, 3. On venter, approximate numbers as follows: abdominal segments IX, 14; VIII, 14; VII, 12; VI, 14; V, 11; IV, 13; III, 7; II, 2; metathorax, 8; mesothorax, 11; prothorax 4; head, 4.

Multilocular disc pores on both surfaces. On dorsum, arranged in simple transverse rows on abdominal segments, few and without particular arrangement on thorax, and absent on head; approximate numbers as follows: abdominal segments VIII, 7; VII, 3; VI, 14; V, 12; IV, 9; III, 8; II, 6; metathorax, 8; mesothorax, 5; prothorax, 1 or 2 (occasionally). On venter arranged roughly in simple transverse rows on abdominal segments, in groups around coxae on thorax, and absent on head; few pores are present near the anterior margins of abdominal segments V to IX and 1-3 pores on the marginal areas of abdominal segments II to VIII; approximate numbers as follows: abdominal segments X, 4; IX, 11; VIII, 25; VII, 25; VI, 20; V, 15; IV, 8; III, 7; II, 1; metathorax, 8; mesothorax, 11; prothorax, 12.

Described from 5 mounted adult females; collected on *Matiola* sp., Burg el Arab, Egypt, April 14, 1934; Holotype and paratypes; the holotype and one paratype are kept in the United States National Collection; one paratype in the British

FIG. 1: *Amonostherium arabicum*, sp. nov.

Museum (Natural History); and other paratypes in the Coccid Collection, Ministry of Agriculture, Egypt, U.A.R.

This species could be easily distinguished from any other species in the genus *Amonostherium* by having six-jointed antennae and two pairs of prominent ostioles.

NOTE. — The inclusion of this species in *Amonostherium* Morrison and Morrison requires some extension in the limits of this genus concerning the presence or absence of ostioles, and the number of antennal joints. As far as these characters are concerned, the definition of *Amonostherium* should be as follows: *Pseudococcidae* with or without ostioles. Antennae short, 6 or 7-jointed.

***Phenacoccus pyramidensis*, sp. nov.**

ADULT FEMALE. — Body narrow, oval, about 1.5 (1.4-1.7) mm. long and 0.6 (0.5-0.7) mm. wide.

With about 10 pairs of cerarii as follows: 2 pairs on head, 3 on prothorax, and 4 or 5 on posterior abdominal segments; on all other body segments, cerarii are either absent or indistinguishable. The anal lobe cerarii with 2 cerarian setae, about 16 microns long; a similar but smaller seta, about 10 microns long, is usually present near the cerarian setae; with about 10 associated trilocular disc pores and 3 auxiliary setae, 5 microns or less in length. Other cerarii with slightly smaller cerarian setae, 10-12 microns long, and about 2-4 trilocular disc pores; every abdominal or thoracic cerarius with 2 cerarian setae while each cephalic cerarius with 3.

Head: Antennae 9-jointed; measurements, in microns, about as follows: I, 30; II, 42; III, 24; IV, 18, V, 24; VI, 24; VII, 24; VIII, 24; IX, 48. Eye bases about 18 microns high and 36 microns in diameter. Beak small, about 60 microns long and about the same in width at base.

Thorax: Legs slightly slender, with a tooth on the claw, measurements of posterior leg, in microns, about as follows: trochanter, 60×24 ; femur, 162×42 ; tibia, 180×30 ; tarsus, 90×18 ; claw, 24; tarsal and claw digitules about as long as claw; claw digitules knobbed, tarsal digitules flagellate. Translucent dots present on all parts of posterior tibia, absent elsewhere. Spiracular apodemes about the same length; 36 microns; anterior pair about 20 microns wide at atrium, posterior pair wider, 30 microns; median portion less than half as wide as atrium in both pairs.

Abdomen: Anal ring apical in position, about 48 microns in diameter; with 6 anal ring setae, each about 84 microns long. Cisanal and obanal setae about the same length, 42 microns. Apical setae about 150 microns long. Circulus absent.

Dermal structures: Ostioles not prominent, anterior lip of thoracic pair and posterior lip of abdominal pair with 3-5 trilocular disc pores and one seta or none; posterior lip of thoracic pair and anterior lip of abdominal pair more developed, each with about 8 trilocular disc pores and 2-3 setae.

Dorsal body setae short and stout; ventral setae long and flagellate on median and submedian areas while similar to the dorsal setae on marginal areas.

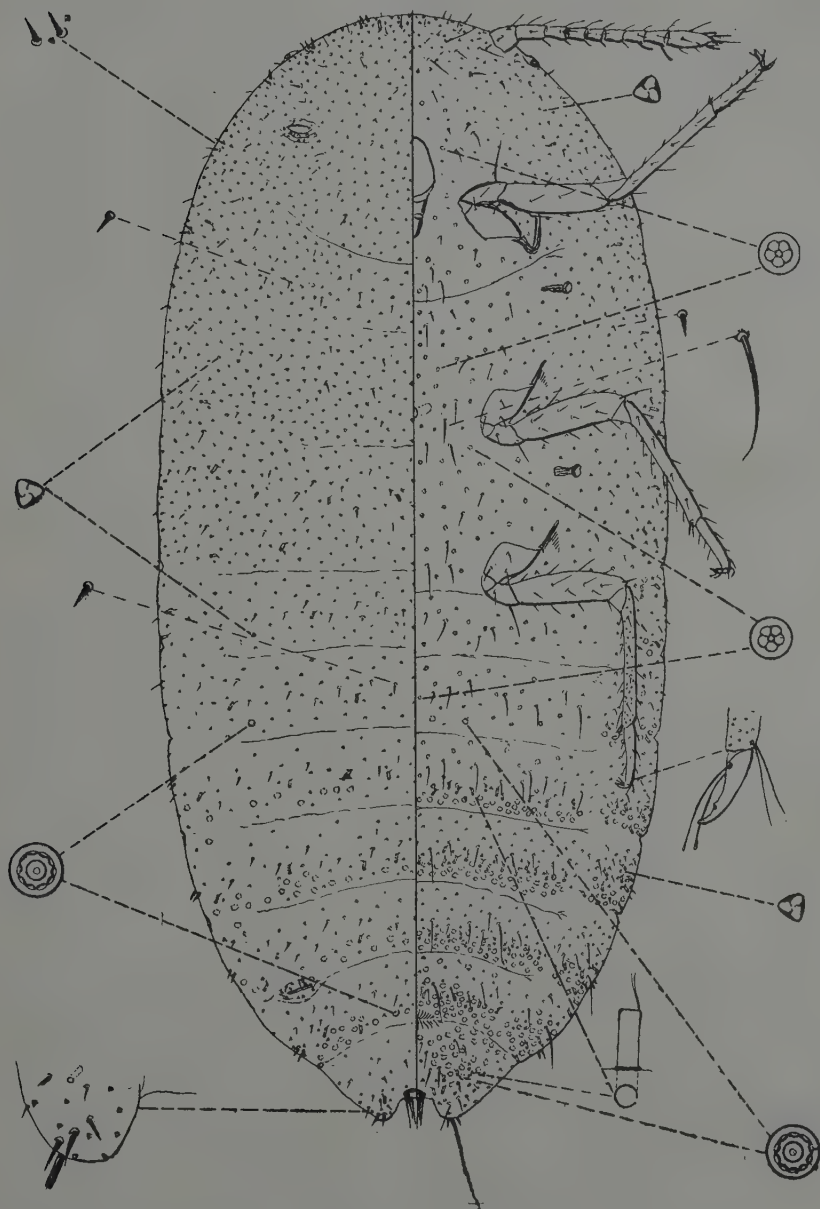


FIG. 2: *Phenacoccus pyramidentis*, sp. nov.

Trilocular disc pores distributed on both surfaces in the usual pattern, spaced 3-6 times their diameter on dorsum, more widely spaced on venter specially where other types of disc pores occur.

Tubular ducts of the oral collar type only. Dorsal ducts about 8×3 microns, arranged on abdomen and metathorax in widely spaced segmental rows of 3-7 ducts in every row; single ducts are present in the lateral areas of mesothorax, prothorax, and head. Ventral ducts slightly smaller, numerous; arranged on abdominal segments V-VIII in marginal groups and segmental rows about 1-2 ducts wide, a small group on lateral areas of segment IX, 1-2 ducts near the margins of segments II, III, and IV; few single ducts are present in marginal and submarginal areas of thorax; apparently absent on head; approximate numbers as follows: abdominal segments IX, 12; VIII, 18; VII, 42; VI, 47; V, 34; IV, 4; III, 4; II, 4; metathorax, 4; mesothorax, 4; prothorax, 4.

Multilocular disc pores present on both surfaces, about 6 microns in diameter, every one with 10 loculi. On dorsum, they are less numerous; roughly arranged in segmental rows on abdominal segments V-VIII, few on segment IV, absent elsewhere; approximate numbers as follows: segments VIII, 28; VII, 12; VI, 34; V, 19; IV, 3. On venter, they are more numerous, mainly arranged in marginal groups and wide segmental rows on abdominal segments V to VIII, widely spread on segment IX, in small groups on the margins of segments III and IV, occasionally few are present on the marginal areas of segment II and median area of segment IV, apparently absent on head and thorax; approximate numbers as follows: abdominal segments IX, 57; VIII, 106; VII, 69; VI, 68; V, 60; IV, 14; III, 3; II, occasionally 1.

Quinquelocular disc pores numerous, scattered over the median and the submedian areas from prothorax to abdominal segment V, few are present on head. One quinquelocular disc pore is present on the dorsum of one specimen near the margin of abdominal segment III; however, it may be considered that such pores are normally absent on dorsum.

Described from 5 adult females from unknown host, Pyramids, Giza, Egypt, holotype and paratypes. The holotype in the United States National Collection, one paratype in the British Museum (Natural History), and other paratypes in the Coccid Collection, Ministry of Agriculture, Egypt, U.A.R.

This species may be considered as similar to *Phenacoccus minimus* Tinsley from the stand point of having the number of cerarii reduced on certain thoracic and abdominal segments which is supposed to be uncommon in the genus *Phenacoccus* Cockerell. On the other hand, this species is readily recognized from *minimus* by having multilocular disc pores on the dorsal surface, dorsal tubular ducts being less in diameter than multilocular disc pores, and circulus absent.

***Spinococcus convolvuli*, sp. nov.**

ADULT FEMALE. — Body oval, about 2.2 mm. long and 1.3 mm. wide.

Usually with 16 pairs of marginal cerarii, frontal and preocular pairs wanting;

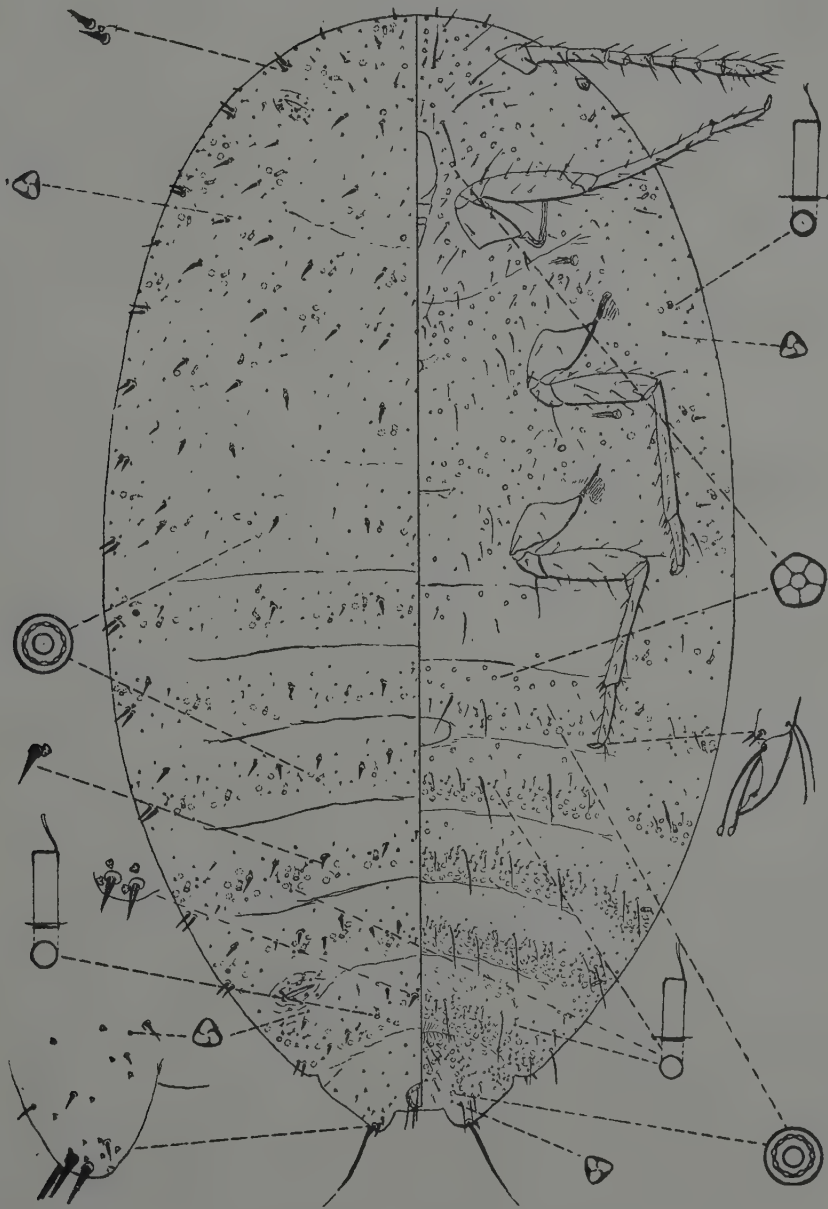


FIG. 3: *Spinococcus convolvuli*, sp. nov.

anal lobe and penultimate cerarian setae stout and conical, about 25 microns long, with about 10 trilocular disc pores and 2-4 auxiliary setae in the anal lobe cerarii; anteriorly, cerarian setae become slightly less stout and shorter, about 20 microns long, all cerarii with not more than two cerarian setae; frequently, some of the thoracic cerarii may have one cerarian seta only, a matter that renders them undetectable for being similar to any of the dorsal stout setae scattered on that area, every cerarius with 2 or 3 trilocular disc pores and no auxiliary setae. In young specimens, the lateral as well as the dorsal cerarii appear on small tubercles.

Head: Antennae 9-jointed; average measurements, in microns, as follows: I, 48; II, 78; III, 60; IV, 30; V, 36; VI, 30; VII, 30; VIII 30; IX. 60. Eye bases about 15 microns high and 30 microns in diameter. Beak broadly conical, about 100 microns long, its width at base is similar to its length.

Thorax: Legs normal, with a tooth on the claw; measurements of posterior leg, in microns, about as follows: trochanter, 84×48 ; femur, 240×72 ; tibia, 270×36 ; tarsus, 102×24 ; claw, 24; tarsal digitules as long as claw digitules, about 24 microns, tarsal digitules pointed but claw digitules knobbed; translucent dots absent. Spiracular apodemes measure, in microns, about as follows: anterior, 50 long, 30 wide at atrium, median portion less than half as wide as atrum; posterior, 54 long, 30 wide at atrium, median portion more than half as wide as atrium.

Abdomen: Anal ring normal, about 90 microns in diameter, with 6 setae, each about 120 microns long. Cisanal and obanal setae shorter, cisanal about 54 microns, obanal 42 microns. Apical setae longer than anal ring setae, about 216 microns. Circulus large, oval, about 90 microns long and 60 microns wide.

Dermal structures: Thoracic pair of ostioles with about 5 trilocular disc pores on anterior lip and 12 on posterior lip; abdominal pair with 10 on anterior lip and 5 on posterior lip. Thoracic pair with no setae on anterior lip and 3-4 on posterior lip; abdominal pair with 2 on anterior lip and sometimes 1 on posterior lip.

Dorsal body setae stout; some as large as, or slightly longer than, the cerarian setae of the corresponding segment; arranged in transverse single segmental rows on abdomen, rather scattered on thorax and head, other stouter but much smaller setae are found all over the dorsum among the larger setae; with a single trilocular disc pore adjacent to the socket of every large dorsal seta, there may be more than one of such disc pores specially in the median dorsal cerarius of abdominal segment VIII where these dorsal large setae appear in a paired condition. Ventral body setae long and flagellate.

Trilocular disc pores are sparsely distributed over both surfaces in the usual pattern, spaced about 4 to 8 times their diameter on dorsum, more widely spaced on venter; other slightly larger trilocular disc pores are associated with the dorsal cerarii as mentioned before.

Tubular ducts of two sizes but all of the oral collar type. The larger ducts about 15 microns long and 5 microns wide at opening; arranged on dorsum in seg-

mental rows, one duct wide on abdomen and more than that on thorax, rather scattered on head; numbers about as follows: abdominal segments VIII, 6; VII, 8; VI, 10; V, 10; IV, 8; III, 10; II, 8; metathorax, 6; mesothorax, 18; prothorax, 10; head, 4; on venter, 1 or 2 of these ducts present on the marginal areas of every segment from abdominal segment VII anteriorly to prothorax; these larger ducts on both dorsum and venter are usually present in some sort of association with multilocular disc pores and with smaller ducts, such grouping is more obvious in young specimens. The smaller ducts are about 12 microns long and 3 microns wide at opening, present on both surfaces; but quite few on dorsum, close to, or scattered among the larger ducts; on venter they are much more numerous on abdomen arranged in segmental rows, about 1-2 ducts wide, getting wider towards the margin, approximate number as follows: abdominal segments IX, 20; VIII, 36; VII, 62; VI, 64; V, 30; IV, 24; and 1-3 ducts in the lateral areas of every thoracic segment.

Multilocular disc pores present on both surfaces, about 8 microns in diameter, each with 10 loculi. On dorsum, they are more or less associated with the tubular ducts; number about as follows: abdominal segments VIII, 24; VII, 25; VI, 28; V, 20; IV, 20; III, 16; II, 8; metathorax, 8; mesothorax, 24; prothorax, 26; head, 10. On venter, they appear near posterior margins of abdominal segments IV-IX in segmental rows, 1-3 ducts wide and some near anterior margins of segments VIII and IX; numbers about as follows: abdominal segments X, 8; IX, 28; VIII, 80; VII, 60; VI, 60; V, 50; IV, 18; few pores are present on the lateral areas of abdominal segments and thorax; apparently absent on head.

Qinquelocular disc pores numerous on median and submedian areas of venter from head to abdominal segment VII, approximate numbers as follows: abdominal segments VII, 4; VI, 12; V, 12; IV, 22; III, 14; II, 0; metathorax, 42; mesothorax, 42; prothorax, 24; head, 12.

Described from the following adult females: 1 specimen on *Convolvulus* sp., Talkha, May 17, 1934, holotype; and the following paratypes: 3 specimens (On two slides) from the same host, Mansourah, Jan. 12, 1934; 1 on *Euphorbia* sp., same locality, Jan. 22, 1935; 1 on *Convolvulus* sp., Nahiah, Dec. 26, 1933; 2 on same host, same locality, Jan. 5, 1934; 2 on same host, Talkha, Jan. 11, 1934; 2 on same host, Sandub (near Mansourah), Jan. 12, 1934; 1 on same host, Shirbin, Jan. 12, 1934; 2 on same host, Talkha, Jan. 15, 1934; 1 on same host, Shirbin, Feb. 5, 1934; 2 on same host, Benha, Feb. 19, 1934; 1 on same host, Talkha, May 17, 1934; 1 on *Mintha* sp., Minia el Qamh, April 9, 1938. The holotype and one of the paratypes in the United States National Collection, two paratypes in the British Museum (Natural History), and all other paratypes in the Coccid Collection of the Ministry of Agriculture in Egypt. In the last Collection, there are other specimens of this species though not considered in the description because of being poor for some reason or another.

This species is similar to *Phenacoccus flaveolus* (Cockerell) but differs by

having less than 18 pairs of cerarii, having a larger circulus, having oral collar ducts of clearly two distinct sizes, and the setae of dorsal cerarii appear in a paired condition on the eighth abdominal segment only.

NOTE 1 — The clusters of multilocular disc pores associated with tubular ducts that appear, specially in young adults, on dorsum and lateral areas of venter indicate certain relationship to *Peliococcus* Borchsenius. However, the condition at hand is not typical of this genus as now understood. Therefore, it is preferred to place this species, in *Spinococcus* Kir. The idea is to put it in the most convenient genus until greater knowledge of the group is acquired.

NOTE 2 — HOSNY published in 1939 a hint about a new *Phenacoccus* under study by Mr. E.E. GREEN as being very common on *Convolvulus arvensis* from localities similar to those of *Spinococcus convolvuli*. No results of this study has ever come to hand. Moreover, HOSNY himself recalls no answer from Green. Therefore, the species under consideration is here described as new. If, by any means, further investigation would prove that GREEN described what HOSNY had mentioned in his publication and that his description is similar to the present description of *convolvuli*, my species is to be sunk as a synonym to that of GREEN's. Until then, *Spinococcus convolvuli* is to stand as a well defined species.

SUMMARY

In this paper, three new mealybugs, family *Pseudococcidae*, are described and illustrated. One species is placed in *Amonostherium* Morrison and Morrison, one in *Phenacoccus* Cockerell, and one in *Spinococcus* Kir.

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HELIOCOCCUS OSBORNI (SANDERS)
REDESCRIBED AS A NEW RECORD FROM EGYPT

[Homoptera: Coccoidea-Pseudococcidae]

(with 1 Text-Figure)

by Y. M. EZZAT,

Department of Zoology, University of Asyût, Egypt.

Through a trial to reorganise the collection of mealybugs in the Ministry of Agriculture, Egypt, some specimens were found without any identification. Few of these proved to be nothing but *Heliococcus osborni* (Sanders), a well known species that occurs commonly in the eastern half of the United States of America. It was collected from El Salloum at the far West of the Northern Coast of Egypt. While declaring this new record a detailed illustrated redescription is thought to be desirable.

The late Prof. FERRIS helped in making the illustration and approved the identification of the species.

Heliococcus osborni (Sanders)

1902. *Phenacoccus osborni* Sanders, and new *Phenacoccus* on *Platanus occidentalis* (Ohio, Nat. 2, pp. 284-286, illus.).
1917. *Phenacoccus pettiti* Hollinger, and new *Phenacoccus* (Homoptera, Homoptera) (*Canad. Ent.*, XLIX, pp. 281-284, illus.).
1950. *Heliococcus osborni* (Sanders), Ferris, G.F.: The Pseudococcidae (Pt. 1) (Atlas of the scale insects of North America V, pp. 99-100, illus).

With 18 pairs of cerarii, every cerarius with two cerarian setae except the ocular pair which has three setae in each cerarius. These setae are stout, short, slightly swollen at the basal half, measuring about 20 microns in the anal lobe cerarii and about 12 microns in other cerarii. Anal lobe cerarii with about 5 associated trilocular disc pores and about 2 auxiliary setae, the integument in this area shows slight sclerotization in well stained specimens; all other cerarii with 1 or 2 associated trilocular disc pores and no auxiliary seta.

Head: Antennae long, 9-jointed; measurements, in microns about as follows: I, 42; II, 66; III, 48; IV, 42; V, 42; VI, 42; VII, 39; VIII, 36; IX, 66. Eye bases about 25 microns high and 40 microns in diameter. Beak conical, about 120 microns long and 100 microns wide at base.

Thorax: Legs with a tooth on the claw; measurements of posterior leg, in microns, about as follows: trochanter, 96×48 ; femur, 246×78 ; tibia, 252×30 ; tarsus, 72×24 ; claw, 32; tarsal digitules flagellate, about 24 microns long; claw digitules knobbed at apex and longer, about 28 microns; translucent dots apparently absent. Anterior spiracular apodemes about 54 microns long and 36 microns wide at atrium; posterior apodemes slightly larger; all apodemes with the median portion less than half as wide as atrium.

Abdomen: Anal ring normal, apical in position, about 90 microns in diameter; with six anal ring setae, each about 152 microns. Cisanal and abanal setae are indistinguishable among several setae existing in their area, ranging from 40 to 45 microns long. Ventral surface of the anal lobe with a broad bar-like sclerotization, which touches the sockets of 2 or 3 setae ranging from 30 to 80 microns long. Apical setae long, about 220 microns. Circulus oval, extending across the middle portion of the line between fourth and fifth segments, about 110 microns long and 60 microns wide.

Dermal structures: Ostioles not sclerotized. Anterior lip of thoracic pair and posterior lip of abdominal pair with about 6 trilocular disc pores and one or no seta. Posterior lip of thoracic pair and anterior lip of abdominal pair with about 10 trilocular disc pores and 1-3 setae.

Dorsal body setae short and stout, similar in shape and sometimes in size to cerarian setae. Ventral body setae long and flagellate on median and submedian areas while similar to dorsal setae on lateral areas.

Trilocular disc pores on dorsum distributed in the usual pattern, spaced 4-8 times their diameter. On venter, these pores are more or less replaced by quinelocular disc pores on median and submedian areas, and more widely spaced than on dorsum on other areas except near the spiracular atria where 3-5 pores appear close together.

Tubular ducts of three types. The first type is relatively large, about 40 microns long and 7 microns wide, opening at the apex of an incomplete sclerotized cone, which carries 3-4 setae near its base; this type is normally on dorsum only, single ducts are present on median or submedian areas of most of body segments, one or two ducts near most of cerarii, and few others apparently without definite arrangement, approximate numbers as follows: IX, 4; VIII, 4; VII, 4; VI, 7; V, 4; IV, 2; III, 3; II, 4; metathorax, 7; mesothorax, 10; prothorax, 10; head, 5. The second type of tubular ducts is similar to the first type though smaller and usually without setae on the cone surrounding the orifice, about 25 microns long and 2 microns wide; present on both surfaces roughly arranged on dorsum in transverse segmental rows about 1-2 ducts wide and getting wider towards the margins on

venter they appear mainly in lateral segmental groups. The third type is much smaller, of the normal oral collar type, about 15 microns long and 4 microns wide on ventral surface only, 2-4 ducts appear close to the posterior margins of abdominal segments V to VIII. and apparently absent elsewhere.

Multilocular disc pores very few, only on the ventral surface around vulva, approximate numbers as follows: abdominal segments X 2; IX, 2; VIII, 4.

Quinquelocular disc pores numerous, greatly replacing trilocular disc pores on median and submedian areas of venter, absent on dorsum.

Redescribed from the following mounted adult females in the Coccid Collection of the Ministry of Agriculture, Egypt: 2 specimens from *Crucianella herbacea*, El Salloum, Egypt, Dr. LABIB. April 17, 1936; 1 specimen from *Onopordon* sp., and carries the same data of the other 2 specimens.

NOTE. — These slides, though collected a long time ago, have been left without any determination, hence this is the first record of this species from Egypt. Meanwhile, no other *Heliococcus* is known to occur in this region of the United Arab Republic.

SUMMARY

This paper declares the existence of *Heliococcus osborni* (Sanders) in Egypt, where no other *Heliococcus* is known to be present. A detailed illustrated redescription of the species is also represented.

LITERATURE

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A REVISION OF THE GENUS *DYSMICOCCLUS* AS KNOWN TO OCCUR IN EGYPT

[Homoptera: Coccoidea-Pseudococcidae]

(with 1 Text-Figure)

by Y. M. EZZAT,

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The genus *Dysmicoccus* was proposed by FERRIS in 1950 in the process of reducing the genus *Pseudococcus* Westwood to a natural group. It proved to be a good genus for including a homogenous group of well-known mealybugs. Three species of *Dysmicoccus* exist in Egypt. All used to be known under the elder genus, *Pseudococcus*. Two of these, *boninsis* and *brevipes*, have been satisfactorily represented in FERRIS' Atlas of 1950, in which they were also transferred to the recent genus under consideration. Although *boninsis* is not a quite typical *Dysmicoccus*, it is advisable to leave it there at least for the time being. The third species, *trispinosus*, is one of Hall's species, originally described from Egypt. This species is here redescribed, illustrated, and placed in its new combination. For practical use, a key separating these three species appears at the end of the paper.

The late Prof. FERRIS took a part in making the illustration, and approved *trispinosus*' transfer to *Dysmicoccus*.

Dysmicoccus trispinosus (Hall) (Comb. nov.)

1923. *Pseudococcus trispinosus* Hall, Egypt. Min. Agric., Tech. and Sci. Serv., Bull. 36, p. 5.

ADULT FEMALE. — Body oval, about 2-3 (2.1-2.6) mm, long and 1.6 (1.3-1.8) mm. wide.

With about 14 pairs of cerarii. Eight pairs of which are on abdomen; the anal lobe cerarius with 2 large cerarian setae, about 100 microns long, with about 5 auxiliary setae, ranging from 10 to 40 microns long and 30-40 associated trilocular disc pores; every other abdominal cerarius with 3 cerarian setae and about 20

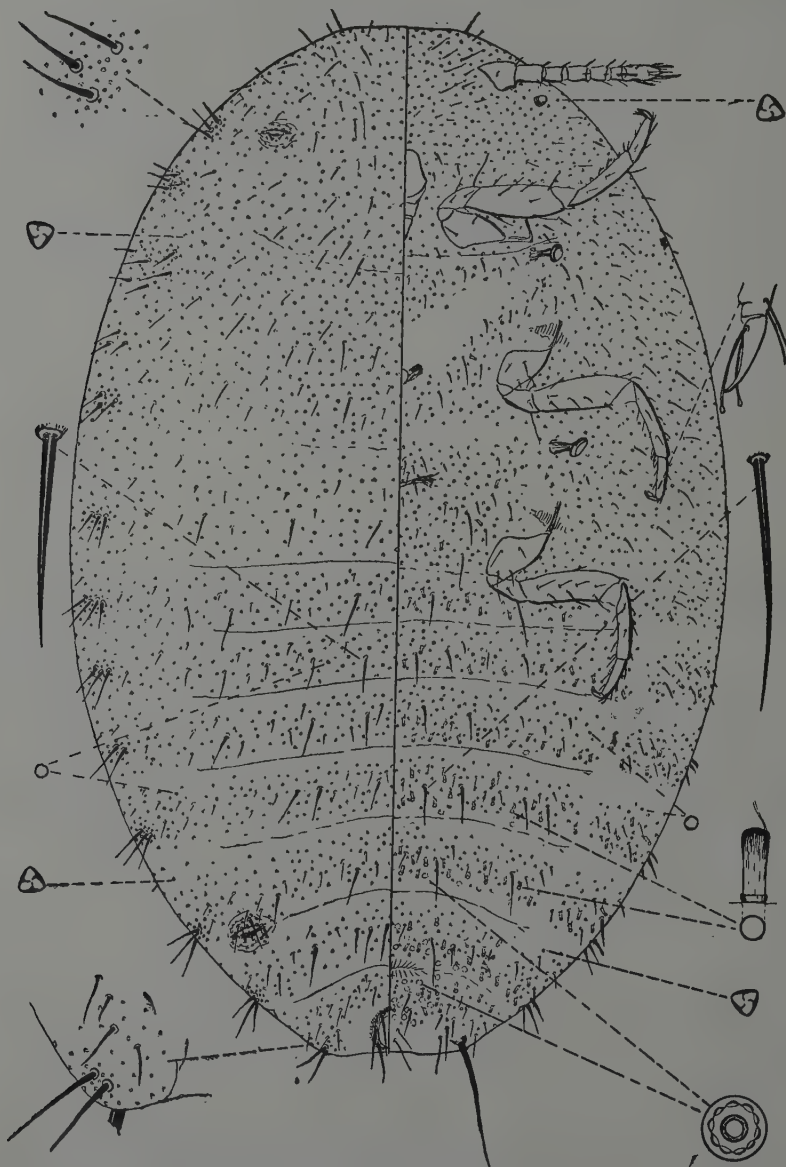


FIG. 1: *Dymmicoccus trispinosus* (Hall) [Comb. nov.]

associated trilocular disc pores. On cephalothoracic region, cerarian setae are grouped at intervals representing about 6 pairs of cerarii, every cerarius with 1-6 cerarian setae and 10-30 trilocular disc pores. Cerarian setae conspicuously long, 60-110 microns, with a general tendency to get shorter anteriorly, they may not be of the same size in the same cerarius.

Head: Antennae normally 7-jointed, a pseudo-articulation may be present in antennal joint IV or VII; measurements, in microns, about as follows: I, 65; II, 60; III, 42; IV, 36; V, 30; VI, 30; VII, 90. Eey bases about 12 microns high and 35 microns in diameter. Beak conical, about 162 long and 132 microns wide at base.

Thorax: Legs normal; measurements of posterior leg, in microns, about as follows: trochanter, 130×75 ; femur, 270×95 ; tibia, 230×50 ; tarsus, 150×30 ; claw, 48; tarsal digitules pointed at tip and relatively short, 28 microns; claw digitules knobbed and longer, 40 microns; translucent dots apparently absent. Anterior spiracular apodemes about 90 microns long, 72 microns wide at atrium; median portion is obviously constricted, about one fourth as wide as atrium; posterior apodemes similar though slightly larger.

Abdomen: Anal ring on dorsum, close to posterior margin, about 135 microns in diameter; anal ring setae 6 in number, variable in length even in the same specimen, ranging from 115 to 144 microns. Cisanal and obanal setae shorter, about 92 and 60 microns respectively. Apical setae longer than anal ring setae, about 240 microns. Ventral surface of anal lobe without a bar, but with a group of about 10 setae ranging from 15 to 56 microns long. Circulus absent.

Dermal structures: Ostioles prominent due to thick elevate lips, every lip with 2-5 setae and 10-20 trilocular disc pores.

Dorsal body setae conspicuously large; ventral body setae similar to dorsal body setae though slightly longer and more flagellate; finer setae are scattered among the large setae on both surfaces.

Trilocular disc pores heavily distributed over both surfaces in the usual pattern, spaced by 4-6 times their diameter.

Tubular ducts of the oral collar type and on the ventral surface only; about 9 microns long and 4 microns in diameter; arranged on most of abdominal segments in transverse rows, about 1-2 ducts wide; few around coxae on metathorax and mesothorax; apparently absent elsewhere; approximate number as follows: abdominal segments IX, 22; VIII, 30; VII, 37; VI, 40; V, 39; IV, 30; III, 15; metathorax, 7; mesothorax, 5.

Multilocular disc pores few, on ventral surface only and mainly in the area around vulva; about 8 microns in diameter and with 10 loculi; numbers about as follows: abdominal segments X and IX, 27; VIII, 19; VII, 1-5; VI, 1-3; V, 2; absent elsewhere.

Simple disc pores about as large as or smaller than trilocular disc pores, scattered over both surfaces; usually those towards the median area are the larger.

Redescribed from the following mounted adult females, all in the Coccid Collection, Ministry of Agriculture, Egypt: 4 cotypes from roots of "halfa grass" (probably *Cladium mariscus*), Nag Hamadi, Upper Egypt, Dec. 11, 1921; 2 cotypes from sugar-cane (*Saccharum officinarum*), same locality, same date. And many other specimens from *Ambrosia maritima*, *Andropogon halepensis*, *Arundo donax*, *Carex comans*, *Chenopodium* sp., *Cynodon dactylon*, *Cyperus* sp., *Eagrotis pilosa*, *Hordium vulgare* (barley), *Panicum colonum*, *P. viricle*, and *Zea mays* (maize); various localities in the Nile Delta, Giza and Nag Hamadi in Upper Egypt; 1924-1939.

This species is readily distinguished from any other *Dysmicoccus* in Egypt, or in any other locality the writer knows, by having those conspicuously large cerarian setae, which are almost always three in number, on every abdominal cerarius except on the anal lobes.

Key to the species of *Dysmicoccus* in Egypt

(Adult Female)

1. Cerarii about 5-6 pairs on posterior abdominal segments in addition to a frontal pair, all with 2 cerarian setae; tubular ducts numerous on dorsum **boninsis (Kuwana)**
 Cerarii about 14 pairs or more, some with more than two cerarian setae; tubular ducts absent on dorsum 2
- 2(1). With about 14 pairs of cerarii, cerarian setae conspicuously long; antennae normally 7-jointed; circulus absent; ventral surface of anal lobes without any sclerotization **trispinosus (Hall)**
 With 17 pairs of cerarii, cerarian setae stout conical; antennae 8-jointed, circulus present; ventral surface of anal lobes with an irregular sclerotized area **brevipes (Cockerell)**

NOTE. — The mealybug *brevipes* (Cockerell) used to be called for sometime in Egypt by its synonym, *Pseudococcus cannae* Green. WILLIAMS has sunk *cannae* as a synonym of *brevipes* since 1958.

SUMMARY

The species *trispinosus* a mealybug originally described by HALL from Egypt is here redescribed and illustrated. It is also referred, in a new combination, to the genus *Dysmicoccus* Ferris. The paper is tailed by a key separating the species of this genus known to be present in Egypt. These are: *boninsis* (Kuwana), *brevipes* (Cockerell), and *trispinosus* (Hall).

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- WILLIAMS, D.J. (1958): The mealy-bugs (*Pseudococcidae*: Homoptera) described by W.M. Maskell, R. Newstead, T.D.A. Cockerell and E.E. Green from the Ethiopian region (Brit. Mus. (Nat. Hist.), Ent. VI, pp. 213-214).
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NEW COMBINATIONS FOR TWO EGYPTIAN MEALYBUGS, WITH REDESCRIPTIONS

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[*Homoptera: Coccoidea-Pseudococcidae*]

(with 2 Text-Figures)

by Y. M. EZZAT,

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Through correspondence with Dr. MORRISON, I received in one of his initiative letters the following paragraph: "I suppose that you have been able to account for all of Dr. HALL's Egyptian mealybugs. We are pretty helpless on this, as we have representatives of only 7 of these". And he ended his letter with this sentence: "I hope that your work is continuing successfully, and that you find time, in the midst of your teaching, to push your studies of the coccids". Being always supported by Dr. MORRISON's encouraging directions, I found nothing better than these statements of his to introduce this paper as well as others planned to deal with Dr. HALL's species.

In this paper, two interesting mealybugs, *albagii* and *cyperi*, are redescribed and illustrated. Accordingly, both had to be transferred from their original genera. The former species is here shifted from *Pseudococcus* Newstead and referred to *Spilococcus* Ferris, while the latter is transferred from *Phenacoccus* Cockerell to *Heterococcus* Ferris.

The late Prof. FERRIS helped in making the decision about the generic status of *albagii* as well as making its drawing.

***Spilococcus albagii* (Hall) (Comb. nov.)**

1926. *Pseudococcus albagii* Hall, Egypt. Minst. Agric. Tech. and Sci. Service, Bull. 72, p. 7.

ADULT FEMALE. — Body oval, about 3.1 (2.1-4.3) mm. long and 1.9 (1.1-2.6) mm. wide.

Normally with 16 or 17 pairs of cerarii; the preocular and sometimes the ocular pairs are missing. Sometimes, the distinguishable number of cerarian pairs

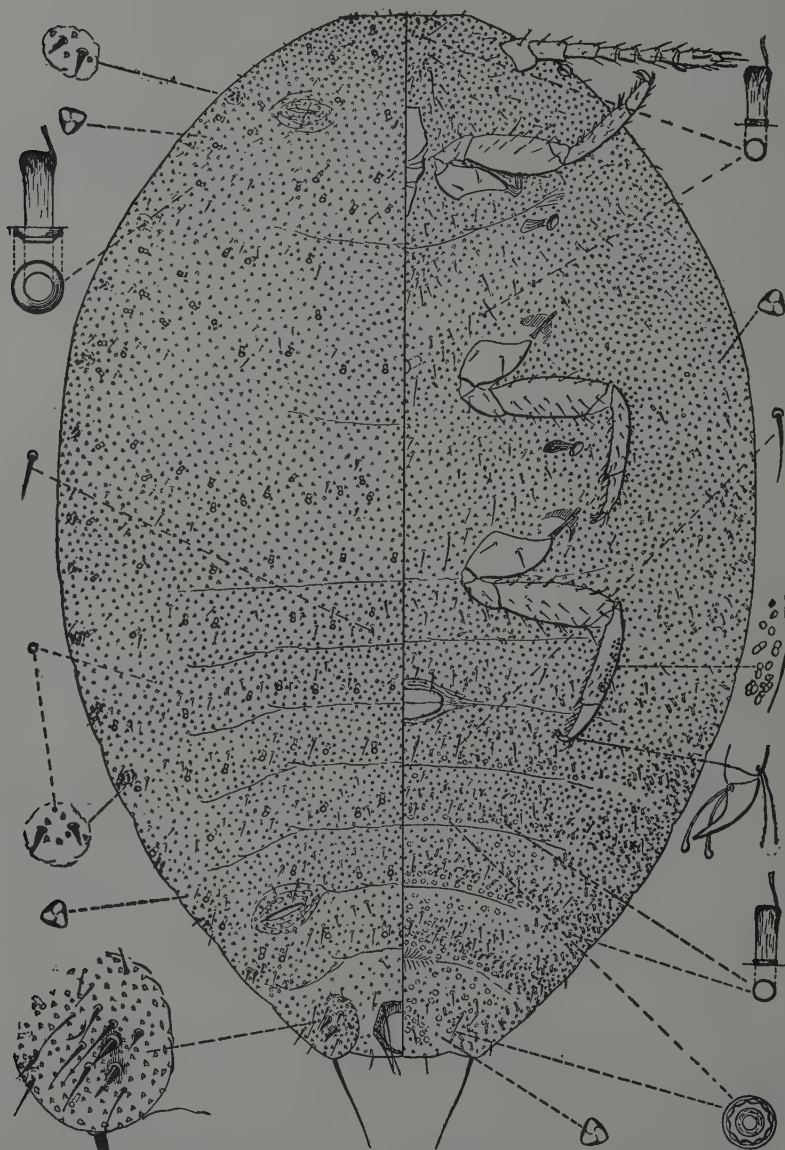


FIG. 1: *Pseudococcus alhagii* Hall (Comb. nov.)

is less than 16 due to the fact that cerarian setae, particularly on thorax, are minute and associated with few pores. Generally, all cerarii with 2 cerarian setae, occasionally 1 or 2 extra setae may be present close to the conical cerarian setae, to which any of the extra seta may be similar in shape. Some cerarii on thorax or head may carry only one cerarian seta. Anal lobe cerarian setae conical, about 12 microns long, associated with about 54 trilocular disc pores and 8 auxiliary setae, ranging from 16 to 35 microns long, one of these setae may be similar to, though smaller than, the cerarian setae. Anteriorly, the cerarian setae become smaller, 7-10 microns long, and the number of trilocular disc pores in the cerarii becomes fewer, from about 10 in the penultimate cerarii to about 3 or 4 in the thoracic and cephalic cerarii.

Head: Antennae usually 8-jointed, sometimes 7-jointed and with or without a pseudo-articulation in joint IV; measurements, in microns, about as follows: I, 60; II, 65; III, 60; IV, 30; V, 35; VI, 30; VII, 35; VIII, 80. Eye bases about 12 microns high and 30 microns in diameter. Beak about 185 microns long and 125 microns wide at base.

Thorax: Legs slightly stout; the common long seta of the trochanter is very short and inconspicuous; posterior tibia with striking translucent dots which are relatively large and may fuse in groups of 2 or more; measurements of posterior leg, in microns, about as follows: trochanter, 120×60 ; femur, 280×100 ; tibia 290×60 ; tarsus, 120×35 ; claw, 40; tarsal digitules flagellate and about as long as claw; claw digitules knobbed and shorter, about 32 microns. Anterior spiracular apodemes about 65 microns long and 15 microns wide at atrium; posterior apodemes slightly larger; median portion in all apodemes less than half as wide as atrium.

Abdomen: Anal ring dorsal, close to the posterior margin, sometimes appearing in an apical position; about 116 microns in diameter, with 6 setae, each about 144 microns long. Cisanal setae about 28 microns long; obanal setae shorter, about 20 microns. Apical setae much longer than anal ring setae, about 208 microns. Circulus conspicuous, broad oval, about 180 microns long and 160 microns wide, extending across the intersegmental membrane between abdominal segments IV and V.

Dermal structures: Ostioles prominent due to considerable elevation. Anterior lip of thoracic pair and posterior lip of abdominal pair with about 14 trilocular disc pores each, the former with about 3 setae, the latter with 1 or no seta. Posterior lip of thoracic pair and anterior lip of abdominal pair with about 18 trilocular disc pores and 5-7 setae on each.

Dorsal body setae short, slightly flagellate. Ventral setae generally longer and more flagellate. On both surfaces, other shorter setae are present among the longer setae.

Trilocular disc pores heavily distributed over both surfaces in the usual pattern, spaced about 2-4 times their diameter.

Tubular ducts of two types. Oral rim ducts on dorsum only, large, about 13 microns long, diameter of opening about 5 microns, of rim about 8 microns; arranged on abdominal segments II to VIII in transverse single rows; on thorax, in rows 1-2 ducts wide getting wider towards lateral areas; on head, few are present in anterior and marginal areas: approximate numbers as follows: 8 ducts on each of abdominal segments VII and VIII, 12 ducts on every abdominal segment from II to VI, 30 on each thoracic segment, and 6 on head. Oral collar ducts on venter only except for few ducts that may appear on the lateral dorsal areas of abdominal segment VIII, small, about 8×3 microns; mainly arranged on abdomen in transverse rows 1-2 ducts wide, being much wider in lateral areas, few ducts on anterior areas of abdominal segments V-VIII; a group of ducts present on lateral posterior areas of metathorax, few ducts around coxae of other thoracic segments; two-groups present on anterior marginal area of head; approximate numbers as follows: abdominal segments X+IX, 52; VIII, 82; VII, 110; VI, 90; V, 74; IV, 30; III, 18; II, 10; metathorax, 16; mesothorax, 6; prothorax, 4; head, 12.

Multilocular disc pores on ventral surface only, with 10 loculi, about 8 microns in diameter; arranged in transverse segmental rows on abdominal segments V to IX, a group on segment X; these rows do not reach the marginal areas, simple on segments V and VI, 1-2 pores wide on segments VII to IX; some pores are present on anterior areas of segments VII to IX; approximate numbers as follows: abdominal segments X, 16; IX, 29; VIII, 52; VII, 42; VI, 18; V, 15; absent elsewhere.

Simple disc pores minute, sparsely scattered all over the body.

Redescribed from the following mounted adult females, all in the Coccid Collection, Ministry of Agriculture, Egypt: 2 cotypes from *Alhagi maurorum*, Maasara, Feb. 26, 1926; 1 cotype from *Echinops spinosus*, same locality, April 4, 1926; 1 cotype from unknown host plant, Heliopolis, April 18, 1926; 5 specimens from *Alhagi maurorum*, near Hawamdia, Aug. 1926; 1 specimen from *Zygophyllum* sp., Wadi el Teeh, May 4, 1932; 3 specimens from *Zygophyllum coccineum*, same locality, May 4, 1933; 10 specimens from roots of *Zygophyllum*, Oct. 18, 1933.

This species, as far as the coccid fauna of Egypt is known, is the only representative of *Spilococcus* Ferris in this State. This genus is readily distinguished from closer Egyptian genera, such as *Dysmicoccus*, *Planococcus*, and *Pseudococcus*, by having two cerarian and no auxiliary setae in the cerarii, and being without an anal lobe bar. These negative characters in addition to the presence of oral rim tubular ducts would easily spot *alhagii* in Egypt.

NOTE. — Dealing with *Spilococcus*, it may be remarkable that the statement which came in volume VI of FERRIS' Atlas, about this genus as being with cerarian pairs varying in number from none to ten, ought to be dropped. This is due to the fact that several North American species, included in volume V of the same Atlas, as well as *alhagii*, possess more than 10 pairs of cerarii.

***Heterococcus cyperi* (Hall) (Comb. nov.)**

1925. *Phenacoccus cyperi* Hall, Egypt. Min. Agric., Tech. and Sci. Service, Bull. 72, p. 4.

ADULT FEMALE. — Body oval, elongate, about 2.4 mm. long and 1.4 mm. wide. Cerarii absent.

Head: Antennae short, 9-jointed (HALL in the original description reported a case of an 8-jointed antenna due to some incomplete articulation); approximate measurements, in microns, as follows: I, 30; II, 24; III, 9; IV, 12; V, 18; VI, 12; VII, 18; VIII, 18; IX, 30. Eye bases about 12 microns high and 24 microns in diameter. Beak small and stout, conical, about 60 microns long and 78 microns wide at base.

Thorax: Legs short and stout, claws with a minute tooth on its inner surface which may skip observation if not mounted in certain position; measurements of posterior leg, in microns, about as follows; trochanter, 48×30 ; femur, 115×45 ; tibia, 112×30 ; tarsus, 63×18 ; claw, 20; tarsal digitules flagellate, about 25 microns long; claw digitules knobbed, about 20 microns long; translucent dots absent. Spiracular apodemes small; anterior pair about 42 microns long and 25 microns wide at atrium; posterior pair about as long as anterior pair but wider, 33 microns at atrium; median portion in all apodemes less than half as wide as atrium.

Abdomen: Anal ring without the outer band of pores, situated close to the posterior margin of the body on dorsal surface, about 60 microns in diameter; anal ring setae short, about as long as the diameter of the ring itself or slightly longer. Cisanal and obanal setae short, cisanal about 28 and obanal 20 microns long. Apical setae missing from the cotypes at hand but reported in the original description as being of the same length as the anal ring setae with a tendency to be less stout. Circulus absent.

Dermal structures: Ostioles devoid of any kind of disc pores or setae.

Dorsal body setae short and flagellate, slightly stout at the basal half. Ventral body setae longer, fine, and flagellate.

Trilocular disc pores absent, more or less replaced by quinquelocular disc pores. These are about 4 microns in diameter, spaced about 3-10 times their diameter on dorsum, the nearer to the margin the more crowded they get, more widely spaced on venter.

Tubular ducts of the oral collar type with the collar very finely indicated, about 7 microns long and 3 microns wide, present on venter only, few in number; arranged on abdomen in simple transverse segmental rows; on thorax along the margin and around coxae; on head without particular arrangement; approximate numbers as follows: abdominal segments X, 2; IX, 8; VIII, 10; VII, 10; VI, 8; V, 8; IV, 8; III, 6; II, 2; metathorax, 10; mesothorax, 10; prothorax, 12; head, 10.

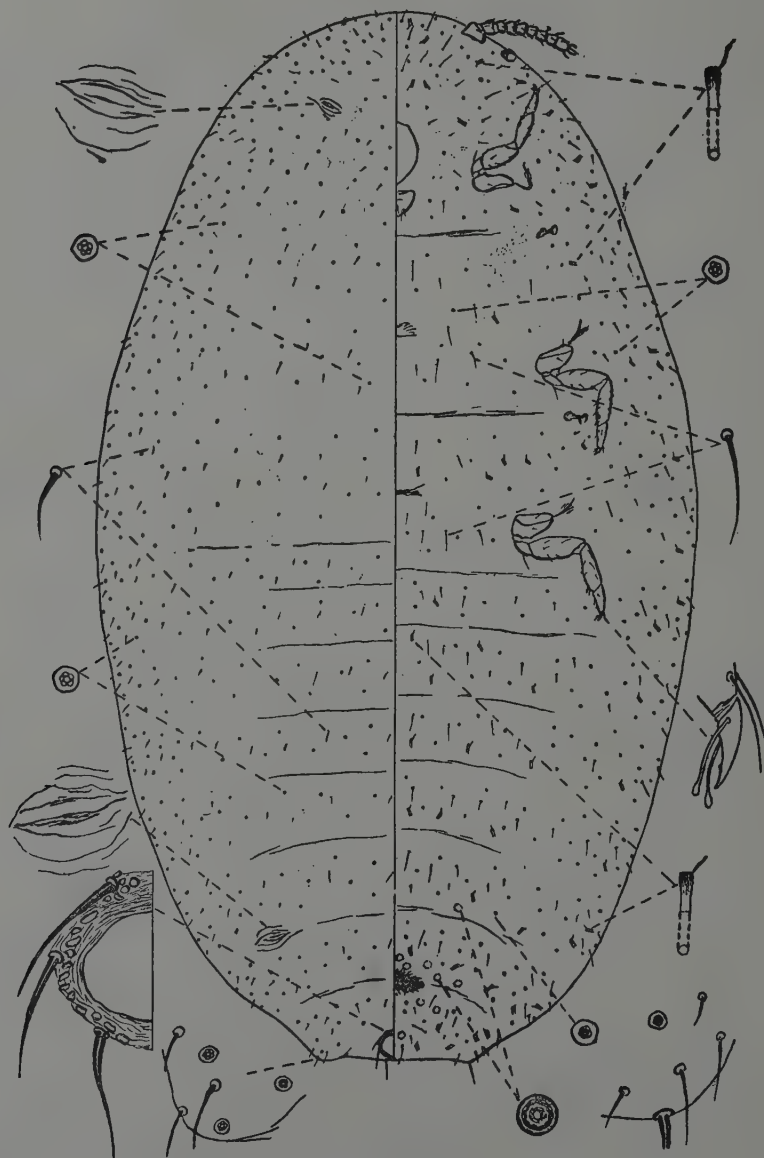


FIG. 2: *Heterococcus cyperi* (Hall) (Comb. nov.)

Multilocular disc pores are few, on the ventral surface only, around vulva, about 6 microns in diameter and with about 10 loculi; approximate numbers as follows: abdominal segments X, 2; IX, 4; VIII, 10; VII, 2; absent elsewhere.

Redescribed from 2 cotypes in the Coccid Collection, Ministry of Agriculture, Egypt, from sedge, Kharga Oasis, Western Desert, Egypt, Dec. 10, 1925.

This species is similar to *Heterococcus arenae* Ferris but differs by having the tubular ducts on the ventral surface only and by lacking an outer band of pores in the anal ring.

NOTE. — FERRIS in 1953 created the genus *Heterococcus* to include three species from North America, three from Europe, and three from Russia. A condition suggesting the genus to be Holarctic. The introduction of *cyperi*, from the Western Desert of Egypt, into this genus should draw attention to the possibility for *Heterococcus* to exist in other climatic regions. The Egyptian species, as well as other known species of *Heterococcus*, occurs beneath the leaf sheaths of grasses.

SUMMARY

This paper includes two interesting species of Dr. HALL's Egyptian mealybugs. These are *alhagii* and *cyperi*. The former is transferred from *Pseudococcus* Newstead to *Spilococcus* Ferris, while the latter is transferred from *Phenacoccus* Cockerell to *Heterococcus* Ferris. Both species are redescribed and illustrated.

LITERATURE

FERRIS, G. F. (1950-1953): The *Pseudococcidae* (Pts. 1 and 2) (Atlas of the scale insects of North America, V and VI).

THE GENUS *PELIOCOCCUS* AS REPRESENTED IN EGYPT

[Homoptera: Coccoidea-Pseudococcidae]

(with 2 Text-Figures)

by Y. M. EZZAT,

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In old times, a tooth on the claw was the main reason to place a mealybug in *Phenacoccus* Cockerell. Accordingly, this genus had to include a heterogeneous group. Recently, other genera have been created to accept with more comfort many members of this group. The problem at hand represents this feature as it deals with two Egyptian mealybugs originally placed in *Phenacoccus*. These are: *zillae* of Hall which was transferred in 1949 by BORCHSENIUS to his genus *Peliococcus*, and *priesneri* of Laing which is here transferred to the same genus. For better knowledge of these two species, illustrated redescrptions are thought to be useful. Being the only known representatives of *Peliococcus* in Egypt, these two species are separated in a key at the end of the paper.

Gratitude is here due to the late Prof. FERRIS for helping in the illustration of *priesneri* (Laing).

Peliococcus priesneri (Laing) (Comb. nov.)

1936. *Phenacoccus priesneri* Laing, Bull. Soc. Ent. Egypte, p. 80.

ADULT FEMALE. — Body elongate oval, 2.3 (1.9-2.5) mm. long and 1.1 (0.9-1.3) mm. wide.

With 18 pairs of cerarii, sometimes appearing with less than 18 due to the indistinguishable condition of some cerarii on mesothorax, metathorax, and anterior abdominal segments. The cerarian setae in such areas are at times so widely separated that they would skip observation, or there may be one seta only in the cerarius. Such characters along with the fact that the cerarian setae are too small and the

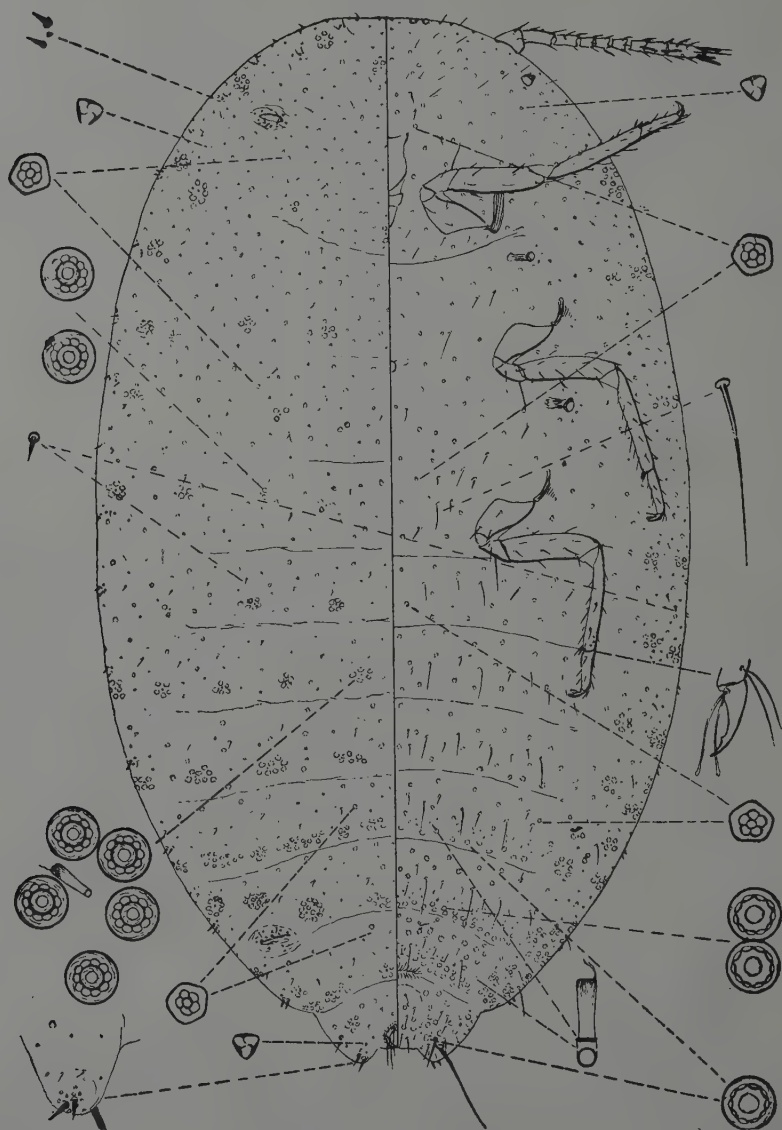


FIG. 1: *Peliococcus priesneri* (Laing) [Comb. nov.]

number of associated trilocular disc pores is very few may reduce the apparent number of cerarii to less than 18 pairs. Anal lobe cerarii with 2 conical cerarian setae, slightly swollen at the basal half, about 15 microns long, with about 12 associated trilocular disc pores and 2 short auxiliary setae, 5-8 microns long. Anteriorly, cerarii get much reduced; cerarian setae gradually decrease in length, starting from about 12 microns long in the penultimate cerarii down to about 6 microns long in the cephalic cerarii; associated trilocular disc pores also decrease from about 6 in the penultimate cerarii to about 2 or even 1 in the cerarii of median and anterior body segments; auxiliary setae wanting except for an occasional short one in the ocular pair.

Head: Antennae 9-jointed; measurements, in microns, about as follows: I, 35; II, 40; III, 30; IV, 24; V, 30; VI, 25; VII, 30; VIII, 25; IX, 48. Eye bases about 12 microns high and 25 microns in diameter. Beak small, as long as wide at base, each dimension about 72 microns.

Thorax: Legs with a tooth on the distal third of the claw; measurements of posterior leg, in microns, about as follows: trochanter, 60×36 ; femur, 168×48 ; tibia, 174×30 ; tarsus, 84×24 ; claw, 36; tarsal digitules fine, 35 microns; claw digitules knobbed, about as long as tarsal digitules; translucent dots very few on distal end of posterior tibia only. Anterior spiracular apodemes about 40 microns long, 25 microns wide at atrium; posterior apodemes larger, about 50 microns long, 45 microns wide at atrium; median portions in all apodemes is more than half as wide as atrium.

Abdomen: Anal ring normal, on dorsum close to posterior apex of body, about 80 microns in diameter; anal ring setae slightly longer than diameter of anal ring, about 100 microns. Cisanal setae about 54 microns long, obanal setae about 35 microns. Ventral surface of the anal lobes without any bar but with a long seta close to the base of apical seta, about 68 microns; and about 5 shorter setae, ranging from 10 to 30 microns. Apical setae long, about 164 microns. Circulus absent.

Dermal structures: Ostioles very lightly sclerotized, with elevated lips. Anterior lip of thoracic pair and posterior lip of abdominal pair with 3 or 4 trilocular disc pores but no seta; posterior lip of thoracic pair and anterior lip of abdominal pair with 6-10 pores and 2-4 setae.

Dorsal body setae very short, conical but slightly swollen at the basal half. Ventral body setae much longer, fine and flagellate, with some shorter though fine setae among the longer setae; on the marginal areas of venter, the setae are similar to those on dorsum.

Trilocular disc pores sparsely distributed on dorsum in the usual pattern, spaced 5-10 times their diameter; generally replaced on venter by quinquelocular disc pores except for few near the spiracular atria and on the marginal areas.

Tubular ducts of the oral collar type only, but of two sizes. The larger ducts on venter only, about 10 microns long and 3 microns wide; mostly arranged in

transverse rows, 1-2 ducts wide, these rows do not extend to the lateral areas on abdominal segments VI to VIII, few ducts present on segments IV, V, IX and X, apparently absent elsewhere; approximate numbers as follows: abdominal segments X+IX, 24; VIII, 25; VII, 38; VI, 28; V, 4; IV, 4. The smaller ducts have narrower openings and occur in association with clusters of multilocular disc pores on dorsum and on marginal areas of venter.

Multilocular disc pores on both surfaces, about 8 microns in diameter and with 10 loculi, the appearance of a pore differs on dorsum than on venter; generally arranged in rows or in clusters of 2-9 pores with a tubular duct at the center of every cluster. On venter, they appear in rows, 1-2 pores wide, on abdominal segments VI to IX, few on segments V and X, and in clusters on lateral areas of all body segments except IX and X; approximate numbers as follows: abdominal segments X, 10; IX, 24; VIII, 104; VII, 82; VI, 58; V, 38; IV, 26; III, 18; II, 16; metathorax, 10; mesothorax, 15; prothorax, 16; head, 5. On dorsum, they appear in clusters only, some of these clusters may tend to fuse on posterior segments but still retaining their grouped nature; these groups are arranged transversely in the body segments; approximate numbers of pores as follows: abdominal segments IX, 9; VIII, 49; VII, 67; VI, 92; V, 58; IV, 41; III, 24; II, 29; metathorax, 33; mesothorax, 46; prothorax, 48; head, 20.

Quinquelocular disc pores about 5 or 6 microns in diameter, distributed over both surfaces, more numerous on venter where they mostly replace the trilocular disc pores.

Redescribed from the following mounted adult females, all in the Coccid Collection, Ministry of Agriculture, Egypt: 5 specimens from *Cynodon dactylon*, Dokki (Cairo), Nov. 1, 1936; 5 specimens from same host and locality, Nov. 9, 1936; 2 specimens from "grass similar to *Cynodon dactylon*", Damanhour, collecting date unknown.

NOTE. — Though registered in the original description that paratypes of this species were deposited in the Ministry of Agriculture of Egypt, none was found. Therefore, the material used for the redescription is not quite authentic. All specimens were found without any determination, or were misidentified as "*Phenacoccus zillae* Hall". Matching in general with the original description of *priesneri* of Laing in addition of being from the type locality and type host, the material at hand was considered convenient for redescribing purposes.

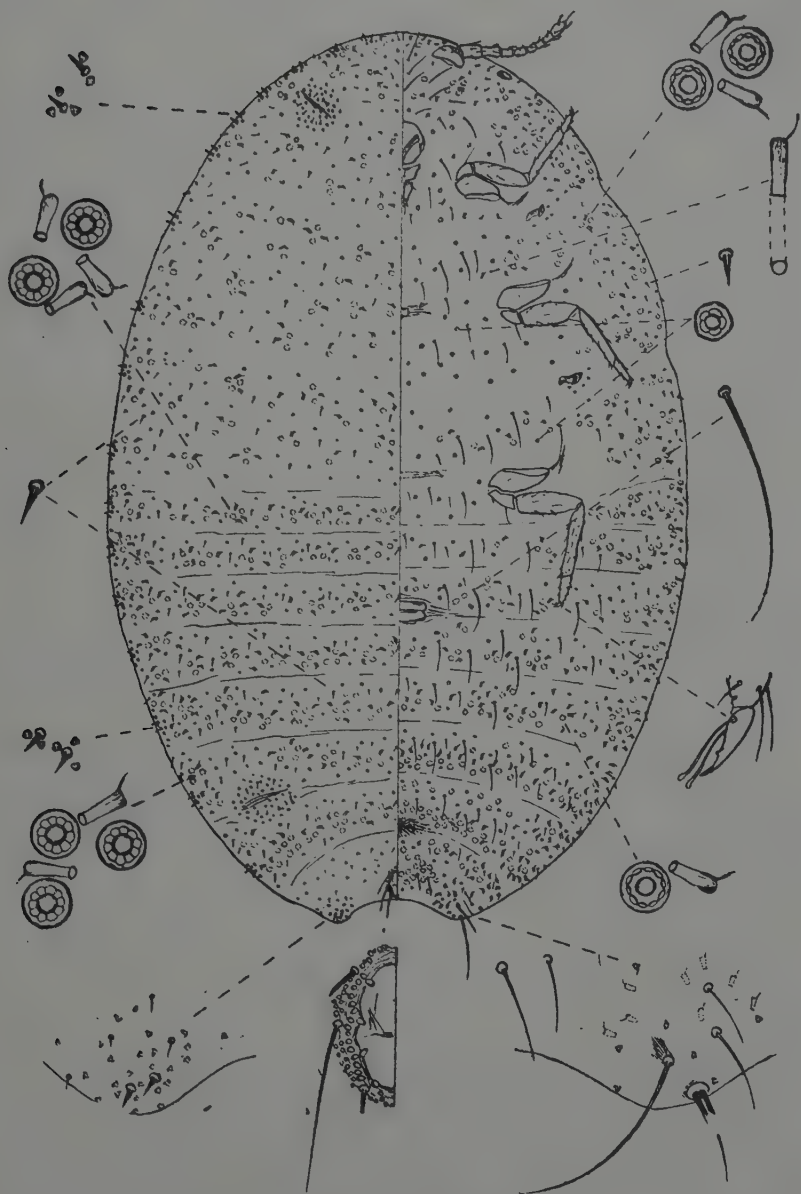
***Peliococcus zillae* (Hall)**

1926. *Phenacoccus zillae* Hall, Egypt. Minist. Agric., Tech. and Sci. Service, Bull. 72, p. 5.

1949. *Peliococcus zillae* (Hall) Borchsenius, *Akad. Nauk. Zool. Inst.*, VII, p. 246.

ADULT FEMALE. — Body oval, about 2.3 (2.2-2.9) mm. long and 1.7 (1.5-1.9) mm. wide.

With 18 pairs of cerarii, with two conical cerarian setae in every cerarius; in the anal lobe pair these setae are about 16 microns long, accompanied with

FIG. 2: *Peliococcus zillae* (Hall).

about 4 short auxiliary setae, ranging from 4 to 8 microns long, and with about 23 associated trilocular disc pores; in other cerarii the cerarian setae are smaller and out 5 microns long, with 4-6 associated trilocular disc pores but no auxiliary setae.

Head: Antennae 9-jointed; measurements, in microns, about as follows: I, 48; II, 68; III, 60; IV, 36; V, 40; VI, 32; VII, 24; VIII, 32; IX, 64. Eye bases about 18 microns high and as twice as this in diameter. Beak conical, about 138 microns long and 108 microns wide at base.

Thorax: Legs normal, with a tooth on the claw; measurements of posterior leg, in microns, about as follows: trochanter, 102×54 ; femur, 222×78 ; tibia, 252×42 ; tarsus, 102×24 ; claw, 36; tarsal digitules flagellate, about 24 microns long; claw digitules knobbed, about 28 microns long; translucent dots few and inconspicuous, on posterior tibiae only. Anterior spiracular apodemes about 60 microns long and 42 microns wide at atrium; posterior apodemes larger; median portion, in all apodemes, more than half as wide as atrium.

Abdomen: Anal ring apical in position, oval in shape, about 108 microns long and 68 microns wide; with 6 setae, each about 120 microns long. Cisanal aetae about 36 microns long; obanal setae slightly shorter, about 30 microns. On the ventral surface of the anal lobe, a very small sclerotized area is present in well stained specimens close to the socket of the longest seta; this seta is about 85 microns long. Apical setae long, about 180 microns. Circulus elongate, extending along the median portion of the intersegmental membrane between abdominal segments IV and V, with a constriction at the folding line, measuring about 160 microns long and 40 microns wide.

Dermal structures: Ostioles moderately prominent, every lip of anterior and posterior ostioles with about 3 or 4 setae and 15 to 20 trilocular disc pores.

Dorsal body setae very short and stout. Ventral body setae long and flagellate on median and submedian areas while similar to dorsal setae on marginal and submarginal areas.

Trilocular disc pores on dorsum distributed in the usual pattern, spaced 4-6 times their diameter; on venter greatly replaced on median and submedian areas from head to anterior abdominal segments by quinquelocular disc pores; otherwise spaced 4-10 times their diameter except near spiracular atria where few pores appear close together.

Tubular ducts present on both surfaces, all of the oral collar type, 8-10 microns long and 3 or 4 microns wide at opening, the larger ducts present close to lateral areas. On dorsum, tubular ducts are usually present in association with clusters of multilocular disc pores, one or more ducts may be present with every cluster according to the size of the cluster; approximate numbers of these pores on body segments as follows: abdominal segments IX, none; VIII, 82; VII, 22; VI, 44; V, 50; IV, 38; III, 38; II, 30; metathorax, 46; mesothorax, 48; prothorax,

24; head, 18. On venter, these ducts are also in association with clusters of multilocular disc pores on marginal and submarginal areas of the body and on median and submedian areas of anterior abdominal segments; otherwise, they may appear singly on submedian areas of thorax, or in transverse rows and lateral groups on posterior abdominal segments; approximate numbers as follows: abdominal segments X, none, IX, 48; VIII, 52; VII, 66; VI, 68; V, 50; IV, 40; III, 26; II, 14; metathorax, 44; mesothorax, 46; prothorax, 36; head, 22.

Multilocular disc pores present on both surfaces, all about 8 microns in diameter and with 10 loculi though their appearance differ according to which surface they are on as illustrated in the plate. On dorsum, these disc pores appear in clusters, the number of pores in every cluster is up to 4 pores or more in association with tubular ducts as mentioned before, the clusters are roughly arranged in transverse segmental rows; approximate numbers of pores on different body segments as follows: abdominal segments IX, none; VIII, 36; VII, 28; VI, 50; V, 44; IV, 41; III, 40; II, 40; metathorax, 49; mesothorax, 64; prothorax, 28; head, 16. On venter, appearing in the same condition of clusters on marginal and submarginal areas of all body, and in transverse rows 1-2 pores wide on posterior abdominal segments, but absent on median and submedian areas of posterior part of head, thorax, and anterior abdominal segments; approximate numbers of pores on different body segments as follows: abdominal segments X, 8; IX, 38; VIII, 67; VII, 47; VI, 38; V, 37; IV, 36; III, 28; II, 24; metathorax, 28; mesothorax, 52; prothorax, 36; head, 22.

Quinquelocular disc pores present on ventral surface only, about 5 microns in diameter; scattered without any particular arrangement on median and submedian areas of head, thorax, and anterior abdominal segments, practically replacing other kinds of disc pores on most of these areas.

Redescribed from the following mounted adult females; all in the Coccid Collection, Ministry of Agriculture, Egypt: 1 cotype from *Zilla spinosa* (aerial), Fayed (near Suez), Oct. 5, 1925; 5 specimens from unknown host-plant, Sallum, Sept. 24, 1926; 2 specimens from *Zilla spinosa*, Wadi-Digla (Helwan), Nov. 16, 1929; 2 specimens from same host-plant, Wadi Om Eleg (Helwan), July 16, 1931.

Key to the species of genus *Peliococcus* Borchsenius in Egypt

(Adult female)

- a. Circulus absent; quinquelocular disc pores on dorsum and venter; trilocular disc pores absent from all abdomen except on marginal areas; generally, multilocular disc pores in a cluster more numerous **priesneri (Laing)**
- aa. Circulus present; quinquelocular disc pores on venter only; trilocular disc pores absent from median and submedian areas of head, thorax, and anterior abdominal segments only; generally, multilocular disc pores in a cluster less numerous **zillae (Hall)**

SUMMARY

In 1949, BORCHSENIUS transferred *zillae* of Hall to his genus *Peliococcus*. In the present work, *priesneri* of Laing is also transferred to the same genus. Both species are here illustrated and redescribed. A key at the end of the paper is constructed to separate these two species.

BIOLOGICAL STUDIES ON CERTAIN RACES OF THE SILKWORM, *BOMBYX MORI* L.

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and

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INTRODUCTION

The races of the silkworm, *Bombyx mori* L., are either univoltine, bivoltine or polyvoltine. The taxonomists consider that these characters are changed owing to the environmental conditions. In the univoltine races, the grains or eggs deposited by the moth in spring do not hatch out until the following spring, having passed the summer and the autumn in aestivation and the winter in hibernation. In the other breeds, the eggs can hatch very soon after being deposited because there is no pause in the embryonic development, thus allowing reproduction of successive generations in the year.

The local breed in Egypt, was a race called "Masry", which gives yellow cocoons, coarse grains; moreover it was failure in giving good quality of raw silk. This breed had disappeared from Egypt after the pebrine epidemic spreading from France in the latter half of the last century.

Many silkworm races, were imported to the Sericulture Department of the Ministry of Agriculture and were distributed without any test for their superiority in the quantity and the quality of silk production.

The present investigations were carried out to make a comparative study on certain characters of some selected imported races of silkworms, especially their adaptability to the local environmental conditions. Each race had been given sufficient study to be accustomed to its special characters, and from the results obtained we can choose the most satisfactory race for breeding in Egypt.

MATERIAL

The silkworm races used in this study were the standard breeds in many countries in the world. During 1957 and 1958, breeding of the different races were carried out in the Faculty of Agriculture, Ains Shams University, and in the Sericulture Department of the Egyptian Ministry of Agriculture. The races used in these investigations were:

In 1957: Gobio, Bagdad, Green, Var, Ungari gelbspinner, Cellar weibspinner, Kitpinih erxopia, Oro chinese, Yinhan×Huachiu, and Huachiu×Yinhan.

In 1958: Var, Ungari gelbspinner, Cellar Weibspinner, Kitpinih erxopia, Oro chinese, Yinhan×Huachiu, and Huachiu×Yinhan.

The Gobio, Bagdad, Green, and Var are considered as local races. They were bred in Egypt since the establishment of the Sericulture Department, in 1926. The races Ungari gelbspinner (U) and Cellar weibspinner (C), were imported by air mail from the German Sericulture Research Station; Kitpinih erxopia was imported from the Sericulture Laboratory of the Ministry of Agriculture in Greece; the hybrid Yinhan×Huachiu and its reciprocal cross were imported from China. The races Gobio (O,) Bagdad (B), and Green(G), were highly infected by the pebrine epidemic during the year 1958.

METHODS

Incubation

Many factors must be considered carefully before making selection of the incubation of silkworm eggs. The most important factors are the local climate, the species and the growing conditions of the mulberry trees in the locality. Incubation, in the right period, is an important measure for enabling the embryos of silkworm eggs to develop normally, and the matured mulberry leaves can be obtained in the proper time.

The grains of the different breeds were weighed and packed in a small paper boxes fitted with muslin cloth for aeration. Incubation took place in an electrical incubator supplied with a source of humidity. The temperature during the incubation period ranged from 23 to 25°C. and the relative humidity from 75 to 80%. The packages were provided with a mesh cloth in the last two days so that the hatched larvae could penetrate through the cloth and leave the egg shell behind. A few tender top leaves were plucked from the mulberry trees and put over the worms which crawled up the leaves gradually. The leaves with the worms were then removed to the rearing trays.

Rearing method

The rearing method must be in accordance with the principal properties of the various species of the silkworms and properly controlled, so that the different breeds should not be mixed with each other during the rearing period.

The rearing room, quite sufficient for breeding 24 grams of grains, was 12 x 6 and 5 metres in height from the floor to the double ceiling. It was provided with windows on each side for the ventilation and light, but the direct sun rays upon the reared worms was avoided. The wooden frames were supplied with four trays, each frame measuring 2 x 0.80 metres and fitted with a boarder of seasoned wood lined with paper which was changed daily. The various breeds of silk worms in the different rearing stages have different requirements, so it was necessary to feed them with properly matured leaves, not too tough nor too tender. The mulberry leaves were supplied to the worms six times daily and were given to the first and second larval instars as stripes, afterwards the diet was distributed in a manner that the larva do not suffocate. Dried leaves and faeces were removed at different intervals by using mosquito netting in the first larval instar, and perforated papers with sufficiently large holes for the other instars.

Spinning

Just before the silkworms are ready to spin their cocoon, bunches of *Casuarina* branches were placed along the trays, the tops being towards each other to form a series of arches. When thousands of silkworms evacuate, the rearing rooms becomes damp, so it is essential that it should be well ventilated and provided with fresh heaps of quicklime in the corner of the room.

Breeding

The selected cocoons for breeding were removed, stripped of the rough floss and carefully strung together in long "necklaces" which were hung from hooks in a dry warm room. The coupled moths were then transferred by the wings to trays carried into a quite room. At the end of the mating periods, the moths were separated and the females were placed in paper bags where they lay their eggs.

Suffocation and drying of cocoons

It is necessary to kill the chrysalis of the selected cocoons for the seric bave test before its transformation, as when the moth pierces the sheath it renders it unreliable. The simplest and easiest manner has been found in the submission of the living cocoons to the action of heat, and the desiccator was used for this purpose. It comprises essentially a fan in the drying chamber in which the fresh cocoons are placed, to maintain a constant air current through the mass of the chrysalids, which carries away the products formed during desiccation, humid and volatile substances and a stove for heating the air driven by the fan. Desiccation was started at a temperature of 50-60°C. After desiccation the cocoons were kept in a dry storage.

RESULTS

Eggs are deposited in paper bags. They vary in size according to the different races, and are either adherent or not adherent. In the present investigations the eggs of the race Bagdad are not adherent, while the eggs of the other nine races are adherent. The weight also varies in the different races. A study of the data shows that the number of grains ranged between 1331 to 1787 per gram in the tested races, as follows: Oro chinese 1787, Hauchui 1624, Var 1586, Bagdad 1457, Ungari 1387, Gobio 1380 and Cellar 1331.

The egg colour was greenish metallic grey in the races Gobio, Ungari and Cellar, while it was metallic grey in Bagdad and Kitpinih, pale metallic grey in the Var and greenish grey in the race green and Oro chinese. In the cross breed Yinhan and Huachui, the colour of eggs is copper grey.

Fecundity

The number of eggs deposited varies in the different races. It is realised from the data obtained that the maximum number obtained was in the cross breed Yinhan, while the minimum number was in the race Bagdad. The average number of fertilized eggs varied from 250 to 609. Parthenogenetical reproduction was not observed in the cross breeds Yinhan and Huachui, while it was highly evident in the races Green, Gobio and Ungari.

Incubation

The incubation of the fertilized eggs varied between seven and eight days at 23-25°C. and 70% relative humidity in the first experimental year, and six to ten days in the second year. There are variations in the incubation period of the different breeds. Hatching took place normally in the early hours in the morning. In the first day a few hatched larvae appeared gradually and the maximum number of the hatched larvae was in the second day.

The hatching period was two days in the cross breeds and races Yinhan, Celler, Huachui, Green and Bagdad, three days in the races Var and Gobio, five to six days in the Oro chinese, Ungari, and Kitpinih.

The larval stage

Data indicate that the larval period ranged from 34 to 43 days at 23-25°C and 70-75 R.H. It is observed that there was little variation in the average duration of the larval stage in the different races. The race Yinhan and its reciprocal cross are considered the quickest strains for it completes its larval period in 34 days.

Moulting

The silk worm passes through three to four moulting stages in the different races. The experimental breeds were from the fourth moulting type. The results

show that the premoulting period ranged between 24 to 51 hours in the first, second and third instars, while it took between 24 and 70 hours in the fourth premoulting, in the different races.

The silk worm has five instars to reach its mature stage. The first stadium ranged from five to seven days, while the second, third and fourth ranged from four to six days. The period of the fifth stadium ranged from four to ten days during the two years of the experiments.

Growth

The rapidity with which the process of growth takes place and the increase in size and weight that accompanies it, is particularly evident. Growth is however interrupted at each ecdysis and just after this process occurs an appreciable fall in weight takes place.

The increase in weight varies according to racial and other environmental conditions. After hatching, the average weight ranged from 0.4 to 0.5 milligrams, the weight of larva in the first instar varied from 4 to 8.4 milligrams and in the second instar the weight was between 17 and 33.2 mgms. The weight of the third instars ranged between 118 and 180 mgms, while it was between 575 and 977 mgms in the fourth instar. The average weight of the mature larva ranged from 2.8 to 3.6 grams.

A comparison of the larval weight of the different races showed that the larva of the cross breed Yinhan was heavier in weight than larvae of the other strains.

Spinning

The pupal period ranged between six and nineteen days in the different races while the average weight of the pupa ranged between 195.4 and 226.6 milligram. The highest mean weight of the pupa occurred in the race Gobio (334.9 mgms) and the least was observed in the cross breed Yinhan (132.3 mgms for the races reared in 1957. The highest mean weight (229.9 mgms) occurred in the cross breed Yinhan in 1958, and the least (221.6 mgms) in the race Oro Chinese.

Coefficient of variation of the mean weight of the pupal weights of the ten breeds shows that the highest variability was among the race Ungari, i.e. 51.4%. The races Kitpinih, Var, Huachui and Green were next regarding their coefficient of variation, viz. 40.72, 36.88; 36.21 and 34.15%, respectively. The strains Bagdad, Gobio and Cellar were next to the previous races as their coefficient of variation were 24.68, 24.75 and 21.46%. The least coefficient of variation (9.32% occurred among the race Oro chinese.

The average pupal weight in the two years ranged from 195 to 241 milligrams. The highest mean weight of the pupa occurred in the race Kitpinih 241, and the least one (195.4 mgms) in the races Oro chinese and Cellar.

The pelade

The internal layer which envelope the chrysalis is termed the pelade. Its weight, in the different races, was from 4 to 128 mgms with a mean value from 14.2 to 29.9 mgms. Its highest mean weight for the races reared in 1957 was 29.9 mgms in the race Gobio, while the least mean weight was 10.5 mgms in the race Oro chinese. As for the races reared in 1958, the highest mean weight was 18.3 mgms in the race Oro Chinese. The coefficient of variation of the pelade weight was higher in the first experimental year, than the second year, and this may be due to the adaptation of the imported races or also to the infestation by the pebrine epidemic disease in the local breeds.

BIOLOGICAL NATURE OF THE COCOON

The silk gland

The maximum length of the silk gland was found to be 42.9 centimetres in the race Gobio, 41.1, 39.5 and 38.4 cms in the races Huachui, Yinhan, and Bagdad, and 36.1, 35.9, 33.6, 32.2 and 31.7 cms in the races Cellar, Ungari, Var, Kitpinih and Green, respectively. The least length (29.2 cms) occurred in the race Oro chinese. The weight of the silk glands ranged between 0.573 and 1.150 grams. It is concluded, from the comparison of the results, that the weight of the silk gland of the race Gobio, was heavier than the other strains.

Colour of the cocoon

The colour may vary from the silver white of Yinhan, Huachui and cellar breeds to the dull white of the Bagdad strain. It varies from the pale yellow in the races Kitpinih, Gobio and Var, and is golden yellow in the race Oro Chinese. The race green was nominated according to its green colour. The rose tint is peculiar to certain breeds as the race Ungari. The rose colour cocoons, however, are externally tinted and yield internally yellow silk.

Pigment, when present, is not distributed uniformly throughout the length of the bave, but concentrated in certain layers of the cocoon. Its distribution varied with the different breeds. In the races Gobio, Kitpinih, Ungari and Green, the crust is colourless, while the other layers of cortex show little variation of colour to the end of the bave. On the other hand in the golden yellow breed Oro chinese, pigment is found almost concentrated in the upper layers of the cocoon, while the silk reeled from the lower layers vary slightly coloured.

Shape of the cocoon

The common shape of the silkworm cocoons are spherical, oval, and wasted. Cocoons are called ovally shaped when the longitudinal axis is appreciably greater

than the transverse, such as the cocoons of the Yinhan and Huachiu cross breeds. Waisted or built cocoons have the central contraction more or less accentuated, such as in the Bagdad, Kitpinih, Gobio, Var, Green and Ungari races. The spherical cocoons occurred in the races Cellar, and Oro chinese.

The length of the cocoon varies in the different races. The maximum length for the races reared in 1957 ranged from 7.4 to 11.1 cms, the minimum length varied from 5.9 to 10.0 cms, with a mean value ranging from 6.8 to 10.5 cms. The highest length of the cocoon was found in the races Gobio and Bagdad, as their mean length represented 10.5 and 9.5 cms, respectively. The least length was 6.8 in the race Oro chinese. In the races studied in 1958 the maximum length of cocoon ranged from 8.2 to 9.3 cms and the minimum length varied from 6.2 to 8.0 cms with a mean value ranging from 7.4 to 8.6 cms. The highest length of the cocoon was 8.6 cms in the races Var, Huachiu, and Yinhan, while the least length was 7.4 cms in the race Oro chinese.

The width of the cocoon was also measured in the different breeds. In the races reared in 1957, the maximum width varied from 5.0 to 7.5 cms, while the minimum width ranged from 4.0 to 6.4 cms with a mean value varying from 3.6 to 7.2 cms. The highest mean width was 7.2 cms in the race Gobio and 5.8 in the race Bagdad, while the least mean width was 4.6 cms in the race Oro chinese, and the cross breed Yinhan. The maximum width of the cocoon for the races reared in 1958 ranged from 5.3 to 6.8 cms, while the minimum width ranged from 4.4 to 5.1 cms, and their mean ranged from 5.2 to 5.9 cms in the different races. The highest mean width was 5.9 in the race Cellar, and the least one, in the race Var, 5.2 cms.

The highest variability in the cocoon length was among the races Ungari and Gobio, 17.07 and 12.0%, respectively, in the first year, and 13.72% in the race Var in the second year. The highest coefficient of variation of the mean width of cocoon for the races reared in 1957 was 73.21% in the race Cellar, while the least variability in the cocoon width was among the race Gobio 2.7%. In the year 1958, the highest coefficient of variation of the cocoon width was 16.7% in the race Var and the least variability was 3.7% in the race Ungari.

The mean length of the cocoon in the races reared for two years ranged from 7.65 to 8.05 cms and the highest length occurred in the race Ungari. The mean width ranged from 4.65 to 7.75 in the different races and the highest width of the cocoon was found in the race Cellar.

Weight of the cocoon

The cocoons were separately weighed to determine their maximum, minimum and average weight. In 1957, the maximum weight of the fresh cocoon ranged from 1.14 to 2.34 gms, the minimum weight varied from 0.608 to 1.750 grams with a mean value varying from 0.961 to 1.916 grams.

The highest mean weight of the fresh cocoon was found in the race Gobio, Bagdad, and Green. Their weights were 1.936, 1.621 and 1.509 grams, respectively. The race Var and Kitpinih were next to the previous races as their mean weights in fresh cocoon were 1.479 and 1.413 grams. The least mean weight of fresh cocoons was 1.175, 1.112, 0.997, 0.961 grams in the races Ungari, Cellar, Huachiu, Yinhan and Oro chinese, respectively. The maximum weight of the fresh cocoon in 1958 ranged from 1.811 to 2.164 gms, and the minimum weight varied from 1.266 to 1.574 gms. The highest mean weight of the fresh cocoon occurred in the races Ungari, Yinhan, and Var., their weights being 1.574, 1.537 and 1.524 grams. The races Huachiu, Kitpinih, and Cellar were next to the previous strains, weighing 1.495, 1.479 and 1.400, successively. The least mean weight of the fresh cocoon was 1.266 gram in the race Oro chinese.

The maximum weight of the dried cocoon ranged from 400 to 805 mgms and the minimum weight from 190 to 590 mgms, with a mean value ranging from 315 to 673 mgms in the different races reared in the first year. The highest weight occurred in the race Gobio, Bagdad, and Green, their weights being 0.673, 0.563 and 0.505 gram, respectively. The strains Var and Kitpinih were next to the previous races as their mean weight varied from 0.486 to 0.457 gms. The least mean weight was found in the races Ungari, Cellar, Huachiu, Yinhan and Oro chinese, their weights being 0.383, 0.370, 0.357, 0.366 and 0.315 grams, respectively. The maximum weights varied from 554 to 725 mgms, the minimum ranged from 270 to 510 mgms, with a mean value varying from 410 to 613 mgms. The highest mean weight was in the cross breeds Yinhan and Huachiu, their mean weights being 0.613 and 0.612. The race Var, Ungari, and Kitpinih were next to the previous races, their weights being 0.559, 0.556 and 0.515 grams, respectively. The least weight was 0.485 and 8.410 in the races Cellar and Oro chinese.

The mean weight of the fresh cocoons for the races reared in the two years varied from 1.093 to 1.510 grams, while the mean weights of the dried cocoons varied from 427 to 522 mgms in the different races. The heaviest mean weight of the fresh and dried cocoon was 1.510 and 0.522 grams, respectively, in the race Var. The least mean weight occurred in the race Oro chinese. It was 1.093 gram in the fresh cocoon, and 0.362 gram in the dried ones. The highest coefficient of variation of the mean weight of the fresh cocoon in 1957 occurred among the cross breeds Yinhan, and Huachiu, 22.18 and 19.54%, respectively, and the least variability was among the race Green, 8.37%.

The highest coefficient of variation of the mean weight of the dried cocoon was 70.9% among the race Oro chinese and the least variability was 14.33% in the race Ungari.

The highest coefficient of variation of the mean weight of the fresh cocoon for the races reared in 1958 was 18.18% in the race Oro chinese, and the least variability was 6.75% in the cross breed Huachiu. The highest variability of the dried

cocoon was that of the race Ungari (56.83) and the least variability was in the race Var (18.6%).

The mean number of fresh cocoons per kilogram varies from 500 to 907 in the different races, the number of dried cocoons per kilogram varies from 1470 to 2595. It is evident, from the data obtained, that the major number of fresh and dried cocoons per kilogram occurred among the races Oro chinese, Huachiu, Cellar and Ungari, their numbers being 907, 840, 807 and 727 fresh cocoons and 2595, 2107, 2250 and 2197 dried cocoons, respectively. The races Kitpinih, Yinhan, Var, Green, Bagdad and Gobio were next to the previous strains their numbers being 699, 683, 670, 660 and 550 fresh cocoons and 2050, 2105, 1995, 2000, 1710 and 1470 dried cocoons per kilogram, respectively.

Weight of the silk

The maximum weight of the realizable silk ranged from 163 to 240 mgms and the minimum weight from 16 to 112 mgms, with a mean value ranging from 96.2 to 201.6 mgms in the races reared in 1957. The highest weight was found in the races Gobio and Bagdad, 201.6 and 167.5 mgms, respectively; the least weight was 96.2 mgs in the race Oro Chinese. The maximum weight obtained from the races reared in 1958 ranged from 126.2 to 336 mgms, while the minimum weight ranged from 38 to 160 mgms, with a mean value ranging from 116.3 to 235 mgms. The highest weight occurred in the cross breed Yinhan and Huachui, 235.4 and 232.2 mgms. The least weight was that of the race Ungari.

The mean value of the silk weight of the races reared for two years ranged from 111.3 to 175.4 mgms. The highest weight occurred in the cross breed Yinhan and Huachui, being 175.4 and 173.2 mgms, respectively. The races Kitpinih, Var, Ungari and Cellar were next to the previous races, their weights being 145.4, 141.5, 135.2, 134.3 mgms, respectively, and the least average weight was 117.3 mgms in the race Oro Chinese.

Measurements were done to secure information on the relationship between the weight of the cocoons and silk production. Data indicated conclusively that the weight of the cocoons required to give one kilogram of silk was 2.714 kgs. in the cross breeds Yinhan and Huachiu. The races Green, Oro chinese, Cellar, Kitpinih, Ungari and Var were next to the previous races, as the weight of cocoons required for reeling one kilogramme of silk was 3.267, 3.293, 3.308, 3.361, 3.68, 3.481 and 3.508 kgms, respectively. The maximum weight of cocoons required for reeling one kilogram of silk was found in the race Gobio which needed 4.047 kgms of dried cocoons.

The race Var is considered a standard one and was bred in Egypt for a long time. From the data obtained it is clear that it does not represent an economic breeding as it required 3.508 kilos of dried cocoons for reeling one kilogramme of silk, while the two cross breeds Yinhan and Huachiu required 2.714 and 2.743 of dried cocoons, respectively.

SUMMARY

The aim of the present investigations is to study the biological characters of different standard races of the silk worm in view of selecting the more profitable race in silk production, suitable for breeding in the Egyptian environmental conditions. Improvements of silk production could be attained through breeding and selection of the prolific races.

Many standard breeds of silkworm were imported from the sericulture experimental stations from different European and Asiatic countries. The investigations deal mainly with the comparison of the characters of ten silkworm strains which were studied in view to compare their larval and pupal stages, the biometrics of the cocoons, the cocoon weight and production of silk.

The results show that the incubation period of the fertilized eggs ranged between 7 and 8 days at 23-25°C and 75% R.H. It was noticed that the shortest incubation period occurred among the cross breed Yinhan and Huachiu.

It was observed that the larval period ranged from 34 to 43 days in the different races and that the shortest one occurred in the cross breed Yinhan and Huachui which lasted 34 and 36 days. The ten studied breeds were from the fourth moulting type.

It was reported that the increase in the larval weight varies according to racial and environmental factors. The mature larva of the cross breed Yinhan was heavier in weight than the larvae of the other strains. It was clearly evident that the pupal period ranged from 6 to 19 days in the different races and the shortest pupal stage was that of the cross breed Yinhan. The average weight of the pupa ranged from 195.4 to 226.6 mgms in the different races. The highest pupal weight was that of the race Gobio.

The internal layer which envelops the pupa is called pelade and is considered as waste silk. Its weight varied in the different races, ranging from 14.2 to 29.9 mgms. The highest weight of pelade was found to be in the race Gobio.

The colour of the cross breeds Yinhan, Huachiu and cellar was silver white, and dull white in the race Bagdad. The cocoons of the races Kitpinih, Gobio and Var were pale yellow and golden yellow in the race Oro chinese, while those of the race Ungari were rose and the cocoons of the race green were green in colour.

The common shape of the silk worm cocoons are spherical, oval and waisted. The races Cellar and Oro chinese belong to the first type, while the cocoons of the cross breed Yinhan and Huachiu are oval in shape. The cocoons of the other races were of the waisted type.

The average length of the cocoon ranged from 6.8 to 10.5 cms in the races reared in 1957, and from 7.4 to 8.6 cms in the races reared in 1958. The highest mean length of the cocoon was that of the race Gobio.

The average width of the cocoon ranged from 3.6 to 7.2 cms in the races reared in 1957, and ranged from 5.2 to 5.9 cms in the races reared in 1958. The

highest width of the cocoon was that of the race Gobio. It was recorded that the average weights of the fresh cocoons for the races reared in 1957 varied from 0.761 to 1.936 grams, and the highest mean weight was that of the race Gobio. The average weights in 1958 ranged from 1.866 to 1.574 and the highest mean weight of the fresh cocoon was found in the race Ungari.

It is concluded that the average weight of the dried cocoon ranged from 315 to 673 mgms during 1957, and that the highest mean weight was that of the race Gobio. The average weight in 1958 ranged from 410 to 613 mgms, and the highest mean weight of the dried cocoons occurred in the cross breed Yinhan.

The mean number of the fresh cocoons per kilogram varied from 500 to 907 in the different races and the mean number of the dried cocoons ranged from 1470 to 2595.

The major number of the fresh cocoons occurred in the race Oro chinese and the minimum number in the race Gobio.

It is concluded that the average weight of the reelable silk ranged from 96.2 to 201 mgms during 1957 and that the heaviest mean weight of silk occurred in the race Gobio. In 1958, the average weight of silk ranged from 116.3 to 235 mgms and the heaviest one being that of the cross breed Yinhan.

The minimum weight of cocoons required to obtain one kilogram of silk was 2.714 kilos in the cross breed Yinhan, the maximum one being 4.047 kgms in the race Gobio.

It is clearly evident from the present investigations that the race Yinhan and its reciprocal cross Huachiu were the best races bred in the two years of the experiments carried in silk production.

ACKNOWLEDGMENTS

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**ON THE BIOLOGY AND LIFE HISTORY
OF THE PINK BOLLWORM,
PECTINOPHORA GOSSYPIELLA (SAUNDERS)**

[*Lepidoptera: Gelechiidae*]

(with 8 Text-Figures and 4 Tables)

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INTRODUCTION

The biology and life history of the pink bollworm has been studied in widely separated localities, but not much attention was given to the factors of temperature and humidity. The object of this work is to give a clear account of the effect of temperature and humidity on the duration and mortality of each stage of this insect.

Material and technique

Active larvae of *Pectinophora gossypiella* were obtained from infested green cotton bolls collected from different localities. Resting larvae, on the other hand, were obtained from double seeds from different ginneries of Upper and Lower Egypt.

Relative humidities were prepared according to BUXTON (1931), using different concentrations of potassium hydroxide in distilled water. The effect of five temperatures, namely 18, 22, 25, 30.5, and 35.5°C., was tested. This was carried out in an incubator with constant temperature chambers. The effect of four relative humidities, namely 20, 40, 60, and 90% R.H. was also investigated at each of these five temperatures.

For obtaining eggs in large quantities for studying the incubation period at combined temperatures and humidities, about twenty pairs of newly emerged moths were put in a cage one cubic foot capacity with wire sides and a glass cover. Food was provided in the form of dilute sugar solution on a pad of cotton. A branch of cotton plant was introduced daily and was examined every morning and another one was introduced.

The larval instars were reared in "micro-cages" made of glass rings 18×12 mm. stuck to microscopic slides and covered with greased glass covers. In every cage was introduced a single larva when newly hatched from the egg, and provided with a fleshy cotton seed to feed upon. The larvae eat only the contents of the seeds, thus other fresh seeds were provided every day.

When the larvae were fullgrown, they were transferred to small glass tubes 7×1.5 cm. provided with small pieces of cotton and covered with muslin fitted with rubber bands. These were put under the effect of combined temperatures and humidities, 25 tubes were put in every humidity, i.e. 100 in every temperature. They were examined daily until the larvae pupated and moths emerged. The number of died, pupating and non-pupating (resting) larvae, was counted at every test. Examination went on until the death of the adults.

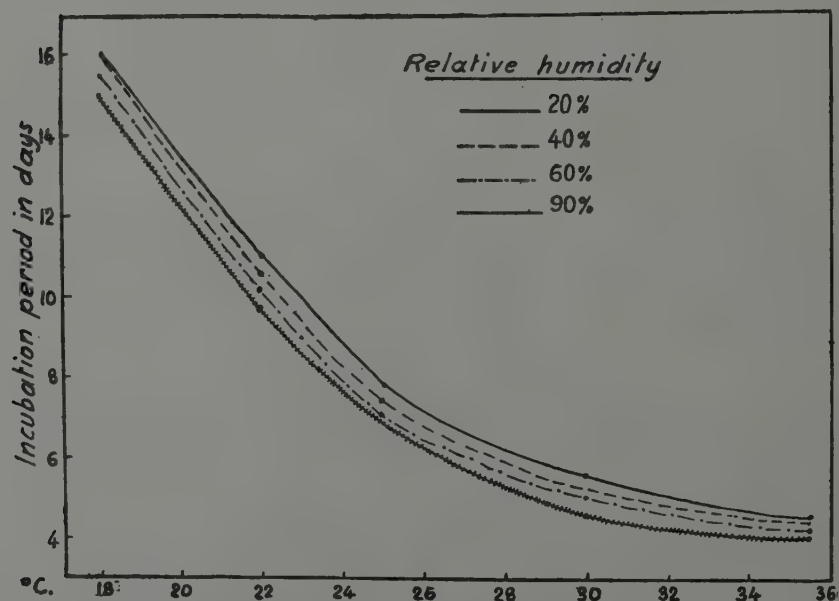


FIG. 1: Effect of temperature and relative humidity on the incubation period of the pink bollworm.

Incubation period

Newly laid eggs were introduced into small glass tubes 60×12 mm. The latter were put in vials 90×20 mm. filled with potassium hydroxide solution to a depth of about 30 mm., to give the desired relative humidities. The vials were tightly stoppered with greased corks and were put under the effect of constant temperatures in an incubator. The effect of four relative humidities, viz. 20, 40, 60 and 90% R.H. was tested at five different temperatures, namely 18, 22, 25, 30.5 and 35.5°C. When the approximate day of hatching was reached, the eggs were examined four times a day, until the last egg hatched. The average incubation period under these conditions is represented graphically in Figure 1.

From the results obtained it appears that the gradual increase in temperature causes a great reduction in the time required for the eggs to hatch. The average incubation period being 15.62, 10.37, 7.37, 5.06 and 4.31 days at temperatures 18, 22, 25, 30.5 and 35.5°C.

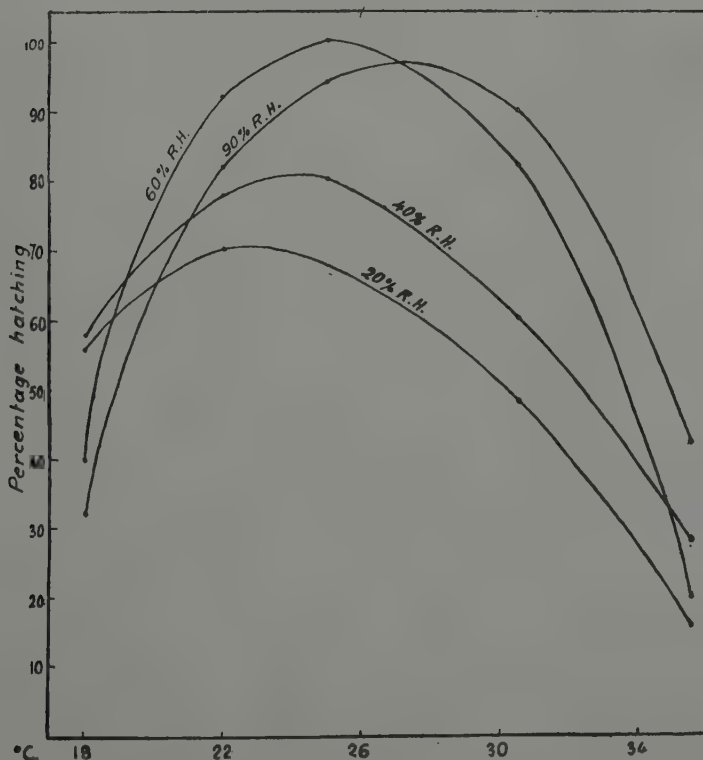


FIG. 2: Effect of temperature and relative humidity on the percentage hatching of eggs of the pink bollworm.

22, 25, 30.5 and 35.5°C., respectively. However, the increase in the duration of the egg stage with the drop of temperature is much more pronounced at lower than at higher temperatures.

Considering the effect of relative humidities, it appears that the incubation period is slightly shorter in higher than in lower relative humidities. When the eggs are placed at 20, 40, 60 and 90% R.H., they hatch after an average time of 8.95, 8.70, 8.45, and 8.05 days, respectively. Decreasing the relative humidity from 90 to 20% results in a slight increase in the incubation period.

It was found that, at high relative humidities, the eggs became mouldy and this made the examination difficult.

Plotting temperature against the percentage hatching (Fig. 2), it can be noticed that hatching is rather high at temperatures ranging from 22 to 30°C. in all relative humidities. The percentage hatching decreases steeply above or below this range. However, the most favourable temperature is 25°C., at which the greatest hatching and the least mortality occur. At 25°C. and relative humidity 60%, the percentage hatching reaches 100%, whereas at 35.5°C. and relative humidity 20%, the percentage hatching is minimized to 16%. Moreover, the resulted larvae die soon after hatching.

Duration of the larval stages

The larval stage of the pink bollworm has been found to possess four instars. The effect of five different temperatures, namely 18, 22, 25, 30.5 and 35.5°C., on the duration of the four larval instars was studied. The effect of relative humidities was excluded, as the larvae must be provided daily with fresh unripe seeds to grow normally. If food is conditioned to the relative humidities intended to be used, the young instars (first and second) die, and the larvae do not attain their normal growth.

As to the effect of temperature, it is well known that the temperature to which the developmental stages of an insect are exposed, has a great influence upon the duration of these stages. This holds good with the developmental stages of the pink bollworm.

The duration period, and percentage mortality of each larval instar at each temperature are given in Figure 3 from which it appears that the duration of the first instar gradually shortens with rise in temperature. The maximum duration is reached at 18°C. where it lasts for an average of 5.2 ± 0.182 days, and the minimum duration is at 30.5°C., where it lasts for an average of 2.6 ± 0.183 days. Between these two extremities, the average duration is 4.2 ± 0.208 days at 22°C., and 3.7 ± 0.186 days at 25°C.

Mortality of this instar at temperatures 18, 22, and 25°C. is more or less equal, being 69, 72, and 70%, respectively. It increases with rise in temperature, so it is 88.5% at 30.5°C., and 100% at 35.5°C. Thus, it appears that it is difficult

to breed this instar at the latter temperature. As a whole, the percentage mortality in the first instar is higher than in the other three instars in all temperatures.

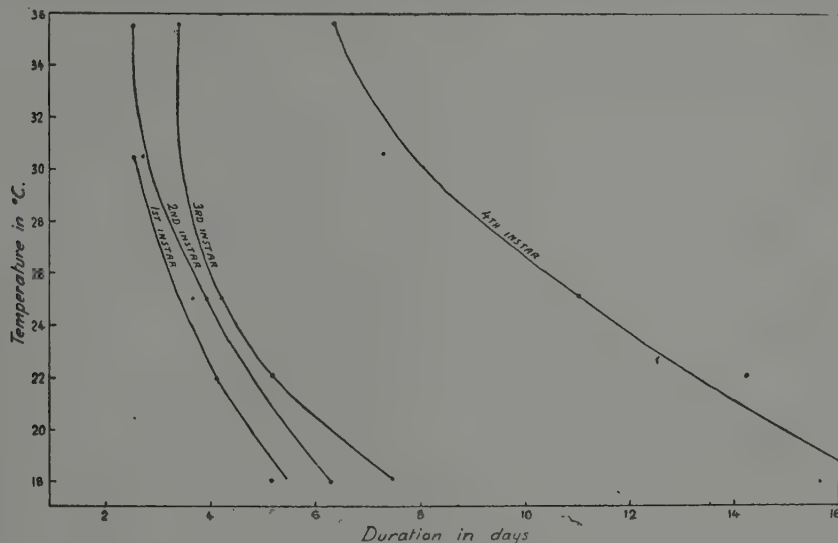


FIG. 3: Effect of temperature on the duration of the larval instars of the pink bollworm.

In the second instar the same gradation in the average duration is found under different temperatures, being 6.3 ± 0.242 days at $18^{\circ}\text{C}.$, 4.2 ± 0.262 days at $22^{\circ}\text{C}.$, 4 ± 0.201 days at $25^{\circ}\text{C}.$, 2.8 ± 0.18 days at $30.5^{\circ}\text{C}.$, and 2.6 ± 0.4 days at $35.5^{\circ}\text{C}.$ Meanwhile, the average duration of the second instar has increased than the average duration of the first instar under all temperatures used, except at $22^{\circ}\text{C}.$ where both stages last nearly the same time.

The percentage mortality at 18, 22 and $25^{\circ}\text{C}.$ shows little variation from each other, however, much reduced than the corresponding percentage in the first instar under the same temperatures. It increases with increase in temperature up to $30.5^{\circ}\text{C}.$ where it reaches 64%, and still more mortality occurs at $35.5^{\circ}\text{C}.$ where it is found to be 87.5%.

The third instar shows an increase in the average duration, under all temperatures, than the first two instars, being 7.5 ± 0.259 days at $18^{\circ}\text{C}.$, 5.2 ± 0.4 days at $22^{\circ}\text{C}.$, 4.3 ± 0.187 days at $25^{\circ}\text{C}.$, 3.8 ± 0.206 days at $30.5^{\circ}\text{C}.$, and 3.5 ± 0.327 days at $35.5^{\circ}\text{C}.$ At the same time, the average duration follows the same rule of being reduced as temperature increases.

The percentage mortality in this stage is also reduced under all temperatures, except at $35.5^{\circ}\text{C}.$ where it remains high, being 60%, whereas at $25^{\circ}\text{C}.$ there is no mortality. This shows that this temperature is quite suitable for breeding the insect.

The fourth instar (including the prepupal period) shows a very big rise in its average duration under all temperatures. It occupies from about 45 to 59% of the total duration period of the four larval instars, being 15.7 ± 0.458 days at 18°C ., 14.3 ± 0.803 days at 22°C ., 11.1 ± 0.533 days at 25°C ., 7.4 ± 0.282 days at 30.5°C ., and 6.5 ± 0.5 at 35.5°C .

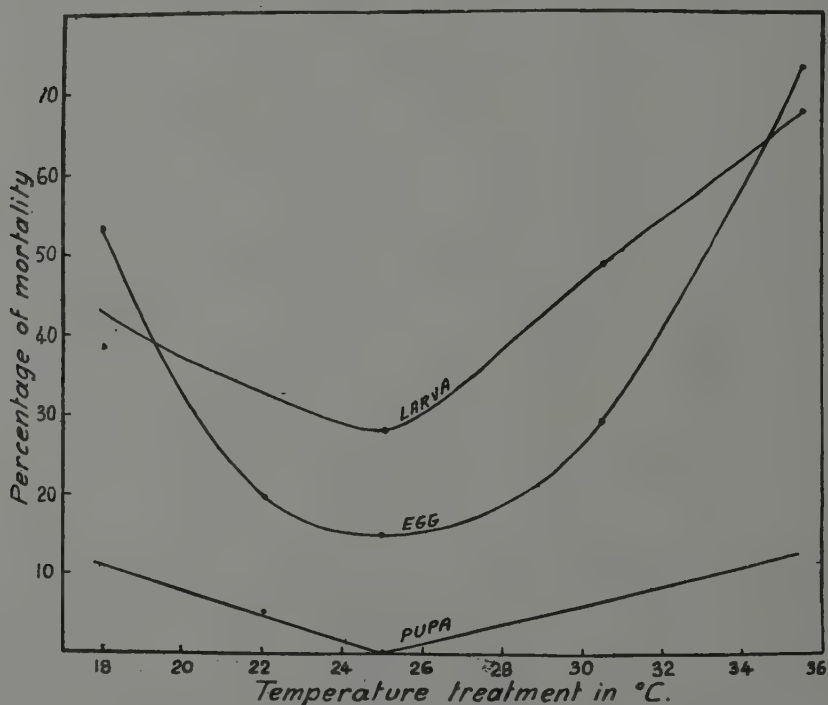


FIG. 4: Effect of temperature on the percentage mortality of the early stages of the pink bollworm.

The percentage mortality in this instar, as a whole, is low, more or less similar to that of the second and third instars at 18°C . However, at 35.5°C . it is much lower, being 25%.

Figure 3 shows that there is a proportional increase in the longevity of each of the four larval instars, with the decrease of temperature.

In conclusion, the average duration of the larval stage decreases gradually as the temperature increases, being 34.7 ± 0.606 days at 18°C ., 27.9 ± 0.957 days at 22°C ., 23.1 ± 0.628 days at 25°C ., 16.6 ± 0.434 days at 30.5°C ., and 12.6 ± 0.718 days at 35.5°C .

TABLE I
Effect of temperature and relative humidity on the duration of the prepupa (in days)

Percentage relative humidity	Average temperature in °C.									
	18		22		25		30.5		35.5	
	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average
20	1-11	8 ± 1.50	1-10	7.1 ± 1.18	—	—	1-4	1.8 ± 0.345	1-4	2.8 ± 0.704
40	1-12	8.2 ± 1.41	1-10	6.7 ± 1.05	1-8	5.2 ± 0.497	1-5	2.8 ± 0.40	1-5	1.5 ± 0.20
60	1-12	7 ± 1.38	1-12	6 ± 0.685	1-9	5.6 ± 0.507	1-6	2.7 ± 0.428	1-5	2.8 ± 0.494
90	1-10	6.1 ± 1.27	1-10	4.1 ± 0.847	1-9	5.3 ± 0.638	1-5	2.4 ± 0.332	1-6	2.5 ± 0.398
Average		7.3 ± 0.697		5.9 ± 0.48		5.3 ± 0.318		2.4 ± 0.189		2.4 ± 0.246

TABLE II
Effect of temperature and relative humidity on the duration (in days) and percentage mortality of the pupal stage.

Percentage relative humidity	Average temperature in °C.													
	18		22		25		30.5		35.5		Average		Average	
	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average
20	24-27	26.0 ± 0.447	16-18	16.7 ± 0.285	16	—	7-9	9.1 ± 0.242	8-9	8.5 ± 0.50	20	15.020 ± .192	24	15.020 ± .192
40	24-28	25.7 ± 0.567	19-20	19.4 ± 0.176	8	11-13	7-9	8.5 ± 0.288	7-9	8.0 ± 1.0	4	14.60 ± 0.238	8	14.60 ± 0.238
60	23-27	25.2 ± 0.523	16-19	17.6 ± 0.221	0	10-13	5-8	7.9 ± 0.214	7-9	8.0 ± 0.169	4	14.10 ± 0.134	8	14.10 ± 0.134
90	21-26	23.7 ± 0.724	15-20	17.7 ± 0.276	0	10-16	6-8	7.5 ± 0.153	6-9	7.4 ± 0.175	4	13.58 ± 0.187	4	13.58 ± 0.187
Average		25.1 ± 0.287		17.8 ± 0.121	5	11.70 ± 0.180		8.2 ± 0.115		7.9 ± 0.285	9		9	

The percentage mortality in the larval stage (Fig. 4) decreases from 18°C. with the increase of temperature until at 25°C., where it reaches its minimum being 28.2%. Above 25°C., it increases with increase of temperature until at 35.5°C., where it reaches 68.1%. At 40°C., the mortality was found to be 100% in all the larval instars.

The Prepupa

When fullgrown, the pink bollworm stops feeding and constructs an oval silken cocoon within which the larva lies, usually at first in a nearly curved position, which gradually becomes less pronounced as the body contracts. The body thus becomes considerably shorter than its original length. It is robust, with its greatest width near the middle, but tapers rather sharply towards the caudal extremity. The head and thorax are nearly of the same width. As pupation approaches, the body becomes sufficiently contracted to leave the skin wrinkled around the caudal extremity.

Duration of the prepupa

The duration of the prepupa as affected by combined different temperatures and relative humidities is shown in Table I. It appears that the duration period, as in the other stages, decreases with increase of temperature and at the same time occupies the least period of all the other stages. From the summarized data, the average duration of the prepupa lasts 7.3 ± 0.697 days at 18°C., 5.9 ± 0.48 days at 22°C., 5.3 ± 0.318 days at 25°C., 2.4 ± 0.189 days at 30.5°C., and 2.4 ± 0.246 days at 35.5°C.

Considering the effect of relative humidities, no regularity can be traced except at temperature 22°C., where it shows a decrease with the increase of relative humidity. From the summarized data, we can conclude that the average prepupal period slightly decreases with the increase of relative humidity, the average being 4.92 ± 0.516 days at 20% R.H., 4.88 ± 0.374 days at 40% R.H., 4.82 ± 0.347 days at 60% R.H., and 4.14 ± 0.347 days at 90% R.H.

Some larvae pupated without spinning cocoons. Such larvae were considered to have a prepupal period of only one day: A maximum duration of 12 days is reached at 22°C. and 60% R.H. and at 18°C. and 40 and 60% R.H. The average duration varies between these two extremities according to different temperatures and humidities.

Duration of the pupal stage

The pupal period, as the other stages, is greatly affected by temperature. The gradual increase in temperature, as shown in Table II, causes a great reduction in the longevity of the pupal stage. From the summarized data, the average duration is 25.1 ± 0.287 days at 18°C., 17.8 ± 0.121 days at 22°C., 11.7 ± 0.18 days at 25°C., 8.2 ± 0.115 days at 30.5°C., and 7.9 ± 0.285 days at 35°C. However, the increase

in the duration period of the pupal stage with the drop of temperature is much more pronounced at lower temperatures than at higher ones.

Considering the effect of relative humidities, it appears that the duration period of the pupal stage is slightly longer in lower relative humidities than in higher ones, in the same temperature, except at 22°C. where it is irregular. The average duration period is 15.02 ± 0.192 days at 20% R.H., 14.60 ± 0.238 days at 40% R.H., 14.10 ± 0.134 days at 60% R.H., and 13.58 ± 0.187 days at 90% R.H.

The mortality in the pupal stage is the least of mortalities when compared to that of the other stages. It decreases gradually from 18°C. till it reaches 25°C. where no mortality occurs. Above 25°C., it increases again, and the average being 6, 5, nil, 9 and 9% at 18, 22, 25, 30.5, and 35.5°C., respectively.

Longevity of the adult moth stage

The life span of the pink bollworm moth varies considerably according to temperatures and relative humidities.

From the results shown in Table III, it appears that in each relative humidity, the longevity of the moth decreases with the increase of temperature. The results obtained show that the average duration is 18.6 ± 1.33 days at 18°C., 11.25 ± 0.791 days at 22°C., 9.23 ± 0.678 days at 25°C., 7.32 ± 1.82 days at 30.5°C., and 3.45 ± 0.413 days at 35.5°C. However, at lower temperatures (18, 22 and 25°C.) and higher humidities (60 and 90% R.H.), some moths possess a duration period of about a month. The shortest period is reached at 35.5°C. and 20% R.H. where the average duration is found to be 1.5 ± 0.5 days. Hence, it is clear that at low temperatures the adults live much longer than at high temperatures. The longevity, as a rule, decreases with rise of temperature at all the relative humidities.

Considering the effect of relative humidities, it appears that the longevity of the moth stage, in contrast with the other stages, increases with the increase of relative humidities. From the summarized data the duration period is found to be 8.5 ± 0.892 days at 20% R.H., 9.32 ± 0.632 days at 40% R.H., 10.6 ± 0.632 days at 60% R.H., and 11.36 ± 0.741 days at 90% R.H.

In conclusion, high relative humidities are more favourable, for the adult life, than low ones at all the temperatures used.

Duration of the life-cycle

The effect of different temperatures and relative humidities was studied, when the larvae were fed daily on fresh unripe cotton seeds to get the normal life-cycle. Larvae which exceed 30 days in the fourth instar were considered resting and were not included in this part of work. The results are shown in Table IV, from which it is apparent that low temperatures retard or prolong the life-cycle, whereas high temperatures accelerate or shorten its duration.

The results obtained show that the life-cycle from the egg till the emergence of the adult is about 75.42 days at 18°C., 56.07 days at 22°C., 42.17 days at 25°C.,

TABLE III
Effect of temperature and relative humidity on the longevity of the unfed moth

Percentage relative humidity	Average temperature in °C.									
	18		22		25		30.5		35.5	
	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average
20	2-22	18.1±2.9	3-20	9.4±1.96	—	—	3-9	5 ±0.499	1-2	1.5±0.5
40	7-22	18.8±1.75	3-19	11.1±1.93	2-14	8.2±0.65	4-8	6 ±0.250	1-4	2.5±1.49
60	9-30	19.5±2.89	6-17	12 ±0.774	4-17	9.9±0.802	3-11	7.4±0.508	2-6	4 ±0.38
90	6-27	18.1±2.9	6-27	12.5 ±1.37	4-31	9.7±1.75	7-16	10.7±0.578	3-8	5.8±0.334
Average		18.6±1.33		11.25±0.791		9.23±0.678		7.32±0.238		3.45±0.413

TABLE IV
Effect of temperature on the average duration of the life-cycle (in days)

Stage	Average temperature in °C.				
	18	22	25	30.5	35.5
Egg	15.62	10.37	7.37	5.06	4.31
Larva	34.7	27.9	23.1	16.6	12.6
Pupa	25.1	17.8	11.7	8.2	7.9
Life-cycle	75.42	56.07	42.17	29.86	24.81

29.86 days at 30.5°C. and 24.81 days at 35.5°C. Figure 5 shows that there is a proportional decrease in the duration period of each stage with the increase of temperature.

In conclusion, temperature seems to be the most important factor affecting the duration period of the life-cycle of the pink bollworm. Of the temperatures used, the most favourable temperature appears to be 25°C., at which the maximum number of eggs is laid and the least mortality in all the immature stages occur. Above or below this temperature, the mortality increases.

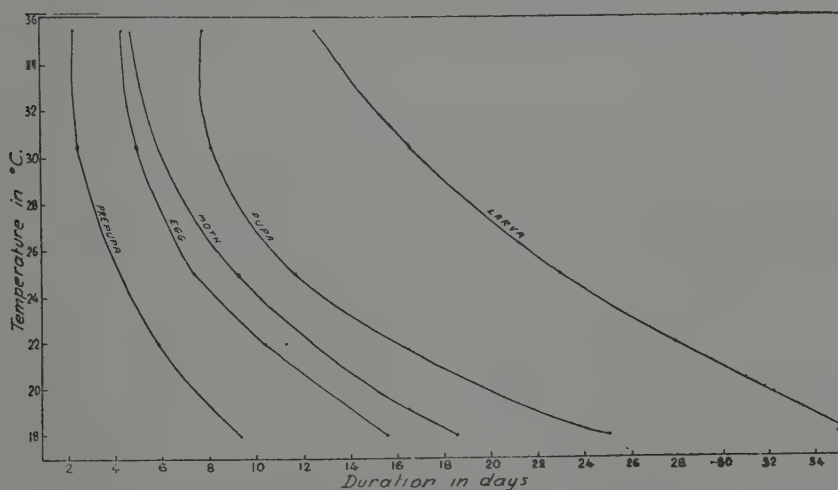


FIG. 5: Effect of temperature on the duration of the different stages of the pink bollworm.

Relative humidities, on the other hand, seem to have a comparatively small effect on the duration period of the immature stages as compared with that of temperature. However, the longevity of the adult increases with increase in relative humidities.

Sexual maturity

The sexual maturity in both sexes is reached on the third or fourth night, but the majority on the third night. By making a smear of the testes in the first two days after emergence, it was found that no mature spermatozoa were present, but appeared only on the third or fourth day, the majority being on the third night.

The ovaries of a newly emerged female are reduced and are bound into a compact mass by the tracheae and fat bodies. No ripe eggs are present in such ovarioles, but there is a series of developing eggs increasing gradually in size from the terminal chambers to the base of the ovarioles.

The ovaries of the older female, three or four days after emergence, are well developed, and ripe eggs are found in them. These eggs lie isolated from each other in the ovariole and the ovarian wall does not adhere loosely to them as it does in the unripe eggs.

Copulation

The mating of moths undoubtedly occurs at night, but it has not been observed by the writer. Pairs of moths were placed in vials $5 \times 2''$ and were examined during the evening at intervals through the night, but the moths were never found in copula. Examinations were done every two hours from the evening till the morning. This was repeated one more with change in the time of examination and the result was the same.

Oviposition

During oviposition, the female stands very quietly on any substratum (leaf or boll) with the head upwards, wings folded, antennae back and legs apart. It raises the body on tip toe, relaxing and resting against the leaf, at intervals, with the

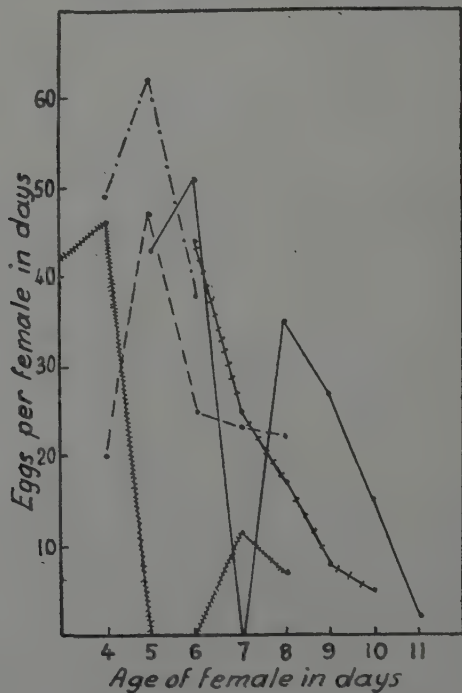


FIG. 6: Rate of oviposition of five pairs of moths.

ovipositor extended. Having laid an egg, it presses it down and flies away. In case of clusters the adjacent eggs are laid by the same female and with the same manner.

It was found that oviposition usually commences in the fourth or fifth night after emergence; however, some females lay eggs on the third night. Oviposition begins at dark and continues throughout the night. With the exception of few nights, the adult female continues egg-laying till its death. The number of eggs laid per night varies greatly, being at maximum in the second night of oviposition and then diminishes steadily (Fig. 6).

The eggs are laid singly or in small groups. During the course of this study the groups of 20-50 eggs and more were met with in captivity.

Egg-laying capacity

The effects of food during the larval stage, of captivity, and of temperature on the egg-laying capacity of the moth were studied.

(a) Effect of food during the larval stage

It was found that larvae which feed upon green seeds or bolls maintain their full size and give rise to large pupae. On the other hand, larvae which feed on dry seeds or bolls, are comparatively small in size, and give rise to small pupae.

Five pairs of moths emerged from large larvae, fed on unripe cotton seeds, and an equal number of moths resulted from small larvae fed on dry or rotten cotton seeds, were put in vials 5×2", one pair in each vial. A small cotton leaf was provided daily for eggs to be laid upon, together with a pad of cotton wetted with dilute sugar solution as a food source. The vials were covered with muslin fitted with rubber bands and were put under room conditions (temperature from 21 to 26°C. and R.H. from 50 to 70%). The cotton leaves were examined daily and the number of the eggs was counted. Examination went on till the death of the moths. From the results obtained it can be seen that in the first group the number of eggs laid per female moth originating from larvae fed upon green bolls varied from 99 to 173 eggs, with an average of 132.8 ± 13.7 , whereas in the second group the number of eggs laid by a single female moth originating from larvae fed upon mature seeds varied from 17 to 73 eggs, with an average of 46.7 ± 13.75 eggs.

(b) Effect of capacity

Ten pairs of moths were bred in a cage one cubic foot with screen sides and a glass cover. A branch of cotton was placed in a small vial filled with water so as to keep it green, and a pad of cotton wetted with dilute sugar solution were introduced into the cage, for moths to lay eggs and to feed upon. The cage was kept in the same conditions with the paired moths in vials 5×2" in the preceding experiment. The result was that, the moths in the cage proved to have an egg capacity of 224.5 eggs per female, whereas in case of moths in vials, they had an egg capacity

of 132.8 eggs per female, as mentioned before. The females bred in both cases were of the large sized ones.

(c) *Effect of temperature*

Newly emerged moths, nearly of the same age, were paired (male and female) in vials $5 \times 2''$ as in the case of the effect of food, and were put under the effect of different constant temperatures in an incubator. The cotton leaves were examined every two days and other leaves were introduced in the vials.

From the results obtained, it appears that 35.5°C . is unfavourable for oviposition and that females seem to be sterile at this temperature. The best oviposition results are obtained between temperatures $22-30.5^{\circ}\text{C}$., the most favourable one being 25°C ., at which the average number of eggs laid per female moth is 87.4 ± 10.2 .

Oviposition decreases below 22°C . and is very much reduced at 18°C . The average number of eggs laid per female moth at 18°C . is 10.7 ± 1.11 .

On dissecting the moths after death in all the already mentioned experiments, great numbers of eggs were found in their ovaries.

Position of eggs on the plant

Eggs are deposited on any green part of the plant. They are mostly found on the small leaves of the growing point and on the shell of the boll, between it and the enveloping calyx; the latter site being the most favourable place. Eggs are also laid on the faeces of the spiny bollworm, *Earias insulana* Boisd., when bolls are infested with the latter.

In captivity, females lay eggs on any provided part of the plant, and even on the walls of the container.

According to the already mentioned points, some reasons are given, within the limits of this study, which seem to be probable for the increase of infestation of cotton with this pest towards the end of the cotton season:

(1) The larvae that feed on green bolls on the earlier part of the bolling season, give rise to large moths which will lay a greater number of eggs towards the end of the season.

(2) The temperature nearly reaches its optimum towards the end of the cotton season, and this temperature increases the number of eggs deposited.

(3) The bolls which are the preferred sites for egg laying, increase towards the end of the season and thus the greatest number of eggs is laid on them.

(4) As the temperature is near its optimum, the majority of eggs hatch. The newly hatched larvae instead of wandering over the plant searching for bolls, as will be mentioned later, will immediately burrow into them and thus they are not exposed to the natural enemies nor to the fatal heat of the sun. Hence, the least mortality and the highest infestation occur.

(5) Moreover, the usual increase in the population towards the end of the cotton season, also increases the infestation of cotton by this pest and the

head is white, polished and soft, when first moulted, but it turns mahogany brown in few hours and then the colour deepens. The thoracic shield and legs are also white when first moulted but soon attain their usual colouration.

Going to pupate, after lasting for a short time as a prepupa, the pupa is disclosed by casting the last larval skin in the same manner.

Habits of the larva

The newly hatched larvae resulting from eggs laid upon parts of the plant other than buds, flowers or bolls are often obliged to wander about, for relatively long distances, over the stems before finding suitable food. It is likely, however, that a large proportion of such larvae perish as a result of exhaustion, exposure to fatal sun heat, attack of predatory enemies and inability to move over wet stems in wet weather.

There is no evidence to suggest that the very young larvae are capable of feeding to any appreciable extent upon any part of the plant except buds, flowers or bolls and it is certain that they can normally mature only in the interior of buds, flowers or bolls.

The young larvae resulting from eggs laid in or in close proximity to flowers, buds or bolls (the majority of larvae), at once penetrate these organs and do not wander over the plant.

The time required for the newly hatched larva to enter the boll was found to be from about 20 to 50 minutes, according to the age of the boll, after which the larva becomes completely hidden.

The entrance holes made by the young larvae in buds or bolls are very minute and can easily be detected, for few days, by the presence of minute particles of the bollwall which have been ejected by the larvae. But these are soon blown away by the wind, or removed by other agents, and the holes close up, leaving only brownish spots which are hard to differentiate with certainty from other discolourations on the boll.

The larva is incapable of migrating from one part of the cotton plant to another and makes no attempt to do so. The young larva is able to crawl very rapidly and, if it has to descend a smooth and upright surface, it secretes a silken thread to accomplish this task.

During the course of this study, the writer has been met with fullgrown larvae outside the seeds and without cocoons. These larvae may spin cocoons twice or three times, and finally, they either remain in the last spinned cocoons or leave them and pupate or die. Other larvae do not spin cocoons at all and in this case they either pupate or die.

One of the most important habits of the pink bollworms is that they appear to be cannibalistic under crowded conditions.

Resting stage

One of the most interesting and at the same time most important, from the practical point of view, in the life history of the pink bollworm is the ability possessed by certain larvae of passing a period of diapause of varying length in a full fed state. This period is termed the resting stage or the long cycle. In this phase the larva completes its normal growth, and instead of spinning the usual cocoon and proceeding to pupate, it constructs an unusual tough, compact, and closely woven cocoon and remains as a larva within it. However, some larvae rest without making any cocoon.

There are no apparent anatomical features or structural differences by which the resting and non resting larvae can be distinguished from each other. It is only by the time taken by them to reach the pupal stage, that one can differentiate between them.

When the larva is ready to go into the resting stage, it remains in the boll in which it has been feeding. Usually, a densely woven cocoon of tough white silk is spun, either in the lint or in the seed. In this case the larva lies in a curved position, head to tail, and the cocoon is spun tightly around it forming a spherical compact mass. Similar cocoons are formed on any substratum or attached to any convenient object, if the larvae are moved from seed or lint.

It was found that the life-cycle of the pink bollworm is short during the earlier part of the season. Later, certain larvae enter the resting stage and the percentage of the larvae which do so, steadily increases until at the end of the season most of the larvae are resting larvae.

It was found that in August, when the temperature is still high and there is yet plenty of food available some of the full fed larvae do not pupate at once, but remain wherever they are, as resting larvae. At the end of October, when the temperature is lower and no food is available, all the larvae develop this tendency and it is the exception rather than the rule for them to pupate.

Thus the resting habit seems to be a combination of aestivation and hibernation, for it begins while food is still available and temperature is high and continues during the winter when food is not available and temperature is low.

(a) *Influence of food.*

Two groups of third instar larvae, each composed of fifty individuals, were reared under room conditions on 25 September, 1957. The first group were fed on dry seeds, whereas the second one was fed on fresh unripe seeds till they were full fed. In the first group it was found that growth is delayed and the larvae do not attain their full size. Of the 50 larvae, only 23 survived and all entered the resting stage, except two larvae which pupated, whereas in the second group all the larvae attained their full size and 20 larvae rested while the other thirty larvae pupated.

Comparing the two results, it appears that in the first case, 82.6% of the living larvae entered the resting stage whereas in the second case only 40% did so. Thus,

it can be concluded that the food, and in particular the dry food, has a great influence on the onset of diapause in the Pink Bollworm.

(b) *Influence of temperature and humidity*

Active full grown larvae were taken out from green bolls, on the fourth of September, 1956, and were placed singly, in small tubes together with a small piece of cotton, and were covered with muslin fitted with rubber bands. Twenty five tubes were introduced in each dessicator of constant relative humidity, under the effect of constant temperature. The effect of four relative humidities, namely: 20, 40, 60 and 90% was tested at each of five temperatures, namely 18, 22, 25, 30.5 and 35.5°C. The larvae remained without pupation after a month from the beginning of the experiment, were considered resting.

The percentage of the resting larvae increases with the lowering of temperature, the average being: 4, 5, 20, 23 and 39% at 35.5, 30.5, 25, 22 and 18°C., respectively.

Considering the effect of relative humidity, it seems that the percentage of the resting larvae slightly decreases with the increase of relative humidities in all temperatures, except at 35.5 °C, where no regularity is traced. The influence of humidity can be clearly noticed in comparing 20 and 90% R.H.; from the summarized results, the average is 21 and 13.6%, respectively. In conclusion, low temperatures and low relative humidities influence the onset of diapause in the pink bollworm.

The results from the two already mentioned experiments may explain, to some extent, the cause of increasing the number of the resting larvae towards the end of the cotton season, as the temperature becomes lower from August onward, and the cotton bolls and seeds become drier towards the end of the cotton season, thus increasing the number of the resting larvae.

Termination of diapause

It was found that moisture is the most important factor terminating the diapause under tropical conditions, and in the field under conditions of heavy rain-

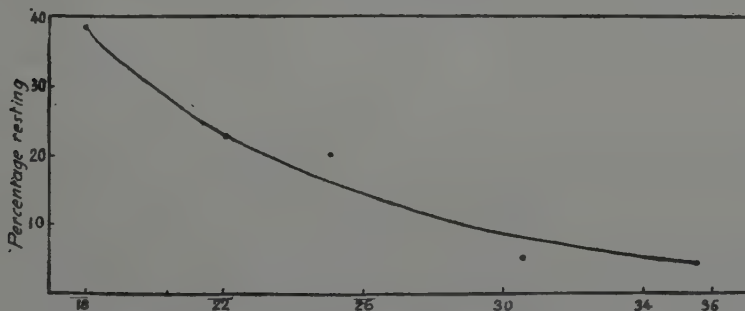


FIG. 7: Effect of temperature on the onset of diapause in the pink bollworm.

fall and high temperature pupation and emergence of the majority of the resting larvae would be completed within $2\frac{1}{2}$ -3 months.

From the results obtained and shown in Figure 7 it can be concluded that high temperature tends to avert diapause while low temperature favours the arrest of growth. Moreover, the effect of chilling, and light on the resting larvae was studied.

(a) *Effect of chilling*

Resting larvae kept at 18°C . were chilled 4, 8, 13 and 18 days at 1°C , and 8, 13, 23 and 33 days at 8°C . The chilled larvae were put under room conditions, on the fifteenth of February 1956, together with control larvae. Ten larvae were used in every experiment, and were examined every five days until all the larvae pupated. From the result shown in Figure 8 it can be noticed that the duration

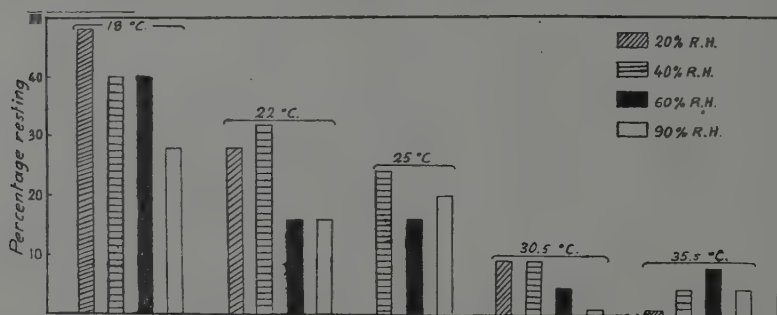


FIG. 8: Effect of combined temperature and humidity on the onset of diapause in the pink bollworm.

period of the resting stage is shortened with increasing the chilling period. The average duration is 55.5 ± 5.9 , 48.5 ± 4.66 , 18.75 ± 2.39 and 16.7 ± 1.67 days when chilled 4, 8, 13 and 18 days, respectively, at 1°C , and 51.5 ± 7.18 , 47.5 ± 4.94 , 36 ± 3.88 and 21.5 ± 2.79 days when chilled 8, 13, 23 and 33 days respectively, at 8°C . The duration period of the control larvae is 52 ± 7.16 days.

Concluding, chilling at 1°C . plays an influential part in terminating the diapause in the pink bollworm, especially when the chilling period is increased.

(b) *Effect of light*

Resting larvae also kept at 18°C were transferred into room conditions on the twenty fifth of March, 1956. They were divided into two groups, 30 larvae in each group. Also 30 larvae were used as control. The first group was exposed to continuous light by artificial illumination, while the second group was kept at continuous darkness by covering the box in which it was contained by black papers. The larvae were examined every five days until they all pupated. The results obtained

showed that 27 larvae of the first group pupated with an average duration period of 29.4 ± 1.95 days, whereas in the second group, 29 larvae pupated with the average duration of 28.9 ± 2.67 days. From the control larvae 26 larvae pupated, with an average duration of 28.6 ± 2.12 days. The remaining larvae, in each case, died.

Thus, it can be concluded that there is no relation between light and termination of diapause.

Pupation

It was found that the larvae leave the boll and pupate on the soil under any shelter. Three hundred green bolls were examined and no pupae were met with inside any of them. On examining one hundred mature opened bolls, thirteen pupae were found in the lint.

In the laboratory, 120 larvae were put in 4 Petri dishes, 30 larvae in each, and were covered with cotton. Of these larvae, 97 entered the resting stage; and on pupating only 11 larvae left the resting cocoon and pupated outside, whereas the other 86 larvae pupated in the resting cocoon. It was also found that resting larvae inside double seeds often pupate in situ.

The adult moth

Emergence usually takes place towards the evening and continues throughout the night. However, some moths were found to emerge during the day, but these are comparatively rare.

The pink bollworm moth is nocturnal in its habits, and all its activities take place at night. During the day, the moths remain concealed in dark places to avoid the day light. If disturbed, it flies for a short distance or runs quickly with a nervous motion, seeking another place of concealment. As dark approaches, however, they become very active, but day light finds them motionless again.

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ANTHOCORIS PEMPHIGI, NOV. SPEC., EINE NEUE ANTHOCORIDEN-ART AUS AEGYPTEN



[Hemiptera-Heteroptera: Anthocoridae]

(mit 6 Abbildungen)

von EDUARD WAGNER, Hamburg

Von kleiner, verhältnismässig schlanker Gestalt, das Männchen $3,0\times$, das Weibchen $3,15\times$ so lang wie das Pronotum breit ist. Hell gelbbraun, glänzend mit Ausnahme von Corium und Clavus, mit feiner, etwas borstiger, halbaufrechter, dichter Behaarung.

Kopf (Fig. 1) schlank. Scheitel beim Männchen $2,4\times$, beim Weibchen $2,5\times$ so breit wie das dunkelbraune Auge. Ocellen gross, dicht am Auge gelegen. Fühler (Fig. 2) kurz, rotgelb, mit halbaufgerichteten, hellen Haaren; 1. Glied dick, etwa so lang wie das Auge; 2. Glied gegen die Spitze verdickt, $2,5-2,6\times$ so lang wie das 1. und $0,9\times$ so lang wie der Kopf breit ist; 3. Glied sehr kurz, nur $0,45\times$ so lang wie das 2.; das 4. Glied $1,25\times$ (Männchen) bis $1,30\times$ (Weibchen) so lang wie das 3.; die Spitzenhälfte des 3. und das 4. ganz dunkel.

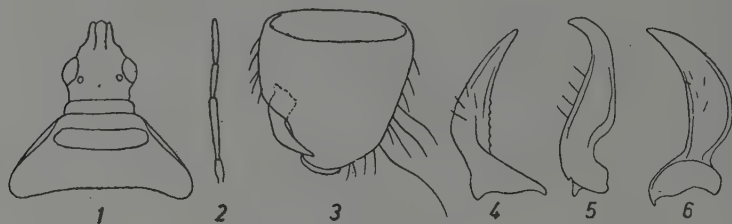
Pronotum (Fig. 1) punktiert, am Vorderrand sehr schmal, zwischen den Vorderecken nicht breiter als der Kopf, nach hinten stark verbreitert und dort $2,2\times$ so breit wie der Kopf. Schwielen zu einer stark erhabenen Querwulst vereinigt, den Seitenrand nicht erreichend. Scutellum vor der Spitze mit kräftigem Quereindruck, dort quengerunzelt. Halbdecken gelbrot. Clavus matt, Corium ausserhalb der Radialader glänzend und weisslich gefärbt, der übrige Teil bis an den Hinterrand matt und gelbrot. Cuneus glänzend, dunkelbraun. Membran weisslich, die hintere Hälfte schwarzgrau, durch eine scharfe, gezackte Querlinie begrenzt. In der Mitte des weisslichen Teils ein grauer Fleck.

Unterseite gelbrot, fast kahl, Connexivum mit dunklen Flecken. Beine gelbrot, mit hellen Haaren, Schenkel und Schienen kräftig, Tarsen schlank.

Genitalsegment des Männchen (Fig. 3) mit nach links gerichteter Genitalöffnung und langen Haaren. Nur der linke Genitalgriffel vorhanden (Fig. 4-6). Er ist spitz,

deutlich gekrümmt, nahe der Basis am dicksten und mit wenigen, feinen Haaren besetzt. Die Aussenkante trägt im proximalen Teil keinen Höcker, die Innenkante 5 winzige Tuberkeln.

Länge: Männchen=3,06 mm, Weibchen=3,15 mm.



FIGS. 1-6: *Anthocoris pemphigi*, nov. spec.

1=Kopf und Pronotum des Weibchen von oben (25 \times), 2=Fühler (25 \times), 3=Genitalsegment des Männchen von oben (54 \times), 4-6=Genitalgriffel des Männchen in verschiedenen Stellungen (120 \times).

A. pemphigi n. sp. gehört nach der Form des Genitalgriffels und dem Glanz der Halbdecken in die Verwandtschaft von *A. nemoralis* F. Diese Art ist jedoch von weit grösserer Gestalt (3,5-4,0 mm lang) und zeigt eine weit feinere, weniger aufrechte Behaarung; die beiden Endglieder der Fühler sind verhältnismässig länger, das 3. Z.B. 0,67-0,80 \times so lang wie das 2.; die Fühler sind stets grösstenteils schwarz, ebenso die Halbdecken; der Genitalgriffel des Männchen ist viel länger und schlanker, hat an der Aussenkante proximal einen spitzen Höcker und an der Innenkante stets Querfalten. Von allen übrigen Arten unterscheidet sich *A. pemphigi* n. sp. durch das bis zum Hinterrande matte Corium und die eigenartige, oben beschriebene Behaarung.

Ich untersuchte 1 Männchen und 1 Weibchen aus Ägypten: Mansoura 10.7.54 an *Populus alba* L. in den Gallen von *Pemphigus napaeus*.

Holotypus in meiner Sammlung, Allotypoid in der Sammlung H. PRIESNER in Linz.

Ich möchte nicht versäumen, Herrn Prof. Dr. H. PRIESNER, Linz, der mir das Material zur Untersuchung zuleitete, auch an dieser Stelle meinen besten Dank auszusprechen.

ZWEI NEUE MIRIDEN-ARTEN AUS SAUDI-ARABIEN

[*Hemiptera-Heteroptera: Miridae*]

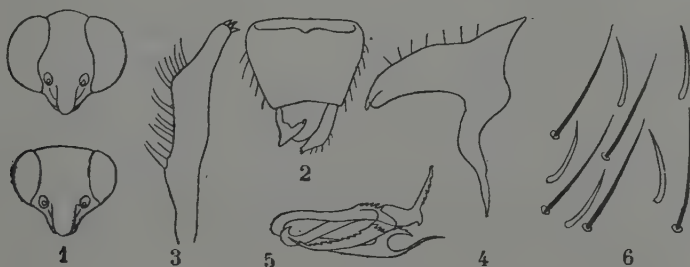
(mit 15 Abbildungen)

von EDUARD WAGNER, Hamburg.

1. *Orthotylus (Melanotrichus) macrophthalmus*, nov. spec.

Von kleiner, länglicher Gestalt, das Männchen $3,2\times$, das Weibchen $3,3\times$ so lang wie das Pronotum breit ist. Hellgrün, Mitte der Halbdecken bisweilen mit rötlichem Schimmer. Behaarung zweifach, aus langen, halbaufgerichteten, leicht gekrümmten, schwarzen Haaren und mehr anliegenden, glänzenden, krausen, weisslichen Haaren bestehend (Fig. 6).

Kopf kurz und breit (Fig. 1) etwas breiter als hoch. Augen sehr gross, fast die ganzen Kopfseiten einnehmend, gekörnt, weisslich. Scheitel hinten ungerandet,



Figs. 1-6: *Orthotylus macrophthalmus*, nov. spec.

1=Kopf von vorn, oben=Männchen, unten=Weibchen ($25\times$); 2=Genitalsegment des Männchen von oben ($25\times$); 3=rechter Griffel von oben ($67\times$); 4=linker Griffel von oben ($67\times$); 5=Chitinbänder der Vesika seitlich ($67\times$); 6=Behaarung der Oberseite.

beim Männchen $1,1\times$, beim Weibchen $1,65-1,7\times$ so breit wie das Auge. Fühlergrube nahe dem inneren Augenrand etwas über der unteren Augenecke gelegen. Fühler grünlich, das 1. Glied dick und $0,30-0,37\times$ so lang wie der Kopf breit ist;

2. Glied stabförmig, so lang oder etwas kürzer als das Pronotum breit ist; das 3. Glied $0,85-0,90\times$ so lang wie das 2., das 4. sehr kurz.

Pronotum trapezförmig, Schwielen deutlich. Halbdecken einfarbig grün, Membran schwarzgrau, Adern etwas heller, hinter der Cuneusspitze ein heller Fleck.

Unterseite hellgrün. Das Rostrum ist schlank und reicht bis zu den Mittelhüften. Beine gelblich oder grünlich. Hinterschenkel beim Weibchen verdickt. Schienen mit hellen Dornen. Die Hinterschiene ist $0,5\times$ so lang wie das Tier und fast $5\times$ so lang wie die Tarsen. Spitze des 3. Tarsengliedes und Klauen schwarz.

Genitalsegment des Männchen (Fig. 2) kurz und breit, trapezförmig. Genitalgriffel sehr gross. Rechter Griffel (Fig. 3) sehr lang und schlank, distal zugespitzt und an der Spitze mit mehreren kleinen Zähnen. Linker Griffel (Fig. 4) hakenförmig, der basale Teil klein, der querstehende Teil gross und breit, Hypophysis klein, leicht gekrümmt und kaum vorstehend, an der oberen Aussenecke eine kräftige, kurze Spitze. Penis gross, Vesika mit 2 Chitinbändern (Fig. 5), die breit und wenig verzweigt sind, deren Ränder aber zum Teil gezähnt sind.

Länge: Männchen= $3,1-3,3$ mm, Weibchen= $3,2-3,35$ mm.

O. macrophthalmus n. sp. gehört wegen seiner zweifachen, aus schwarzen und hellen Haaren bestehenden Behaarung in die Untergattung *Melanotrichus* Reut. Er steht zweifellos *O. flavosparsus* Sahlbg. am nächsten, unterscheidet sich aber von ihm durch die Farbe der Membran, die verhältnismässig langen hellen Haare, das ungewöhnlich grosse Auge, die kleine, schlanke Gestalt und den Bau der Genitalien des Männchen. Auch von allen übrigen Arten ist er leicht durch die Form des Kopfes und den Bau der Genitalien zu trennen.

Ich untersuchte 2 Männchen und 3 Weibchen aus Saudi Arabien: El Riyadh, September 1958, (Dr. DIEHL leg.).

Holotypus und Allotypoid in meiner Sammlung, Paratypoide in der Sammlung H. ECKERLEIN, Coburg.

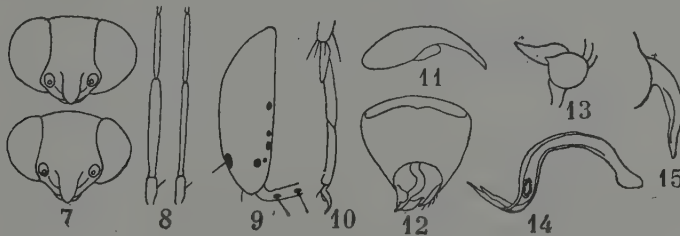
2. *Campylomma minima*, nov. spec.

Von auffallend kleiner Gestalt, länglich oval. Weisslich-grün bis weisslich gelb. Behaarung gelblich, lang und kraus, ziemlich dicht.

Kopf (Fig. 7) sehr kurz, der Tylus überragt die untere Augenkante um weniger als seine Breite nach unten. Auge sehr gross, fast bis zur Kehle reichend, gewölbt. Scheitel beim Männchen $1,05-1,1\times$, beim Weibchen $1,55-1,6\times$ so breit wie das Auge, hinten mit abgerundeter Kante. Fühler einfarbig hell weissgelb, das 1. Glied kurz und dick, innen mit einer Borste (Fig. 8); 2. Glied $3,5\times$ so lang wie das 1., aber nur $0,8\times$ so lang wie der Kopf breit ist, beim Männchen erheblich dicker als beim Weibchen; 3. Glied $0,65-0,67\times$ so lang wie das 2., dünner (das 4. Glied fehlt allen Tieren).

Pronotum kurz trapezförmig, mehr als $3\times$ so breit wie lang, Schwielen undeutlich. Schildgrund zum Teil frei, Schildchen und Halbdecken einfarbig hell, Membran hellgrau, Adern weisslich.

Unterseite einfarbig weissgrün. Das Rostrum hat eine schwarze Spitze und reicht bis zwischen die Mittelhüften. Beine hell ockergelb, Schenkel unterseits schwarz gefleckt (Fig. 9), vor allem an der Hinterkante, an der Vorderkante dicht vor der Spitze ein grösserer Fleck, der eine Borste trägt. Schienen weisslich, mit kräftigen schwarzen Dornen, die länger sind als die Schiene dick ist und aus grossen schwarzen Punkten entspringen, die an den Mittel- und Vorderschienen im Spitzenteil fehlen. Tarsen hell, an den Hintertarsen (Fig. 10) ist das 3. Glied etwa so lang wie das 2. Klauen (Fig. 11) kräftig, mässig gekrümmt, distal spitz; Pseudarolien klein, die Klauenmitte nicht erreichend und mit der Klaue in ganzer Länge verwachsen.



FIGS. 7-15: *Campylomma minima*, nov. spec.

7=Kopf von oben, oben=Männchen, unten=Weibchen (31×); 8=Fühler, links=Männchen, rechts=Weibchen (31×); 9=Hinterschenkel des Männchen von unten (31×); 10=Hinterfuss des Weibchen (66×); 11=Klaue von aussen (266×); 12=Genitalsegment des Männchen von oben (31×); 13=linker Griffel von oben (84×); 14=Vesika des Penis seitlich (84×); 15=Spitzenteil der Theka seitlich (84×).

Genitalsegment des Männchen (Fig. 12) kegelförmig, fast so lang wie breit. Genitalöffnung gross. Rechter Genitalgriffel sehr klein, blattartig, aussen mit langen Haaren. Linker Griffel (Fig. 13) klein, kräftig, der Paramerenkörper rund, Hypophysis lang, spitz und verhältnismässig breit, leicht gewunden, Sinneshöcker mit sehr kurzer, kleiner Spitze. Vesika des Penis (Fig. 14) S-förmig gekrümmt, schlank, distal mit 2 ungleich langen Chitinspitzen; sekundäre Gonopore weit von der Spitze entfernt. Spitzenteil der Theka (Fig. 15) schlank, proximal gekrümmt, distal leicht geschwungen.

Länge: Männchen=2,0 mm, Weibchen=2.15-2.30 mm.

C. minima n. sp. unterscheidet sich von allen übrigen Arten durch die kleine Gestalt, die auffallend grossen Augen und den dadurch sehr kurz erscheinenden Kopf. Sie ist mit *C. impicta* Wagn. und *C. nicolasi* Reut. am nächsten verwandt. Bei *C. nicolasi* ist jedoch das 1.+2. Fühlerglied stets schwarz gezeichnet, das Rostrum überragt die Mittelhüften und das 2. Fühlerglied ist mindestens 0,9× so lang wie der Kopf breit ist. *C. impicta* Wagn. ist grösser, 2,2-2,5 mm lang, hat einen breiteren Scheitel, weit kleineres Auge, das Rostrum erreicht die Hinterhüften und hat anders gebaute Genitalien, z.B. hat die Vesika 3 lange Chitinspitzen.

Ich untersuchte 2 Männchen und 4 Weibchen aus Saudi Arabien: El Riyadh, Sept. + Nov. 1958 (Dr. DIEHL leg.)

Holotypus und Allotypoid in meiner Sammlung, Paratypoide in der Sammlung von Dr. H. ECKERLEIN, Coburg.

Auch Herrn Dr. H. ECKERLEIN, Coburg, dem ich das Material für diese Arbeit verdanke, sei an dieser Stelle noch einmal bestens gedankt.

PRELIMINARY EXPERIMENTS ON THE CONTROL OF SNAP BEAN FLY, *AGROMYZA PHASEOLI* COQ.

[*Diptera: Agromyzidae*]

(with 3 Text-Figures)

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INTRODUCTION

The snap bean fly (*Agromyza phaseoli* Coq.) is the most destructive insect of the snap bean crop in Egypt. It was recorded in Giza by HASSAN (1947) and since that time infestations have been general and destructive all over the country, specially in the Neely crop (MAHER, 1957). The presence of this fly is now recognized to be a limiting factor in producing snap beans in Egypt, a fact which necessitates special attention to be paid to its chemical control. HELY (1947) indicated that DDT proved to be superior to nicotine sulphate. BROWN (1951) recorded that chlordane was more effective than DDT which had superseded nicotine. HASSAN (1947) had shown that treating plants four days after they showed above the ground with a formula containing 1.5% white oil and 2% nicotine sulphate gave better results. Since most of the damage is due to the attack of the insects to young plants, MAHER (1957) recommended that plants should be sprayed when they commence to show above the soil. He showed that parathion proved to be inferior to diazinon and chlordane.

MATERIALS AND METHODS

Experiments were set up in order to determine the effect of certain systemic and non-systemic insecticides against *Agromyza phaseoli* Coq. Preparations used in these experiments were:

(1) 0,0-diethyl-S (ethylthiomethyl)-phosphorodithiate produced by the American Cyanamide Company, and known commercially as Thimet 44-D which contains 50% active ingredient.

(2) 0,0-diethyl-S-2(thioethyl)-ethylester of dithiophosphoric acid produced by Bayer Company, and known commercially as Disyston (=4739) which contains 50% active ingredient.

(3) Diethyl-P-nitrophenylthiophosphate produced by Bayer Company and known commercially as Folidol-E605, an emulsion containing 35% active substance.

(4) Trichloro- α -ethyl-dimethyl-phosphate produced by Bayer Company and known commercially as Dipterex, an emulsion containing 50% active substance.

(5) 0,0-dimethyl-dithiophosphate of diethyl mercaptosuccinate produced by the American Cyanamide Company and known as Malathion, a wettable powder containing 25% active substance.

(6) DDT-Lindane an emulsion concentrate containing 30% DDT+9% Lindane.

Randomized plots replicated four times were planted with Monte Calm snap beans on loam, clay loam and sandy soils at Moshtohor, Kaha and Anshas respectively. Growing of seeds took place on August 17, 1958, at Moshtohor and Kaha, and on August 19, at Anshas.

Each plot consisted of 4 rows, 6 metres long. The distance between ridges and hills was 55 cms. and 15 cms., respectively.

Treating the seeds with Disyston and Thimet 44 D. at the rate of 8 and 2 lbs. per 100 lbs. of seeds, respectively, was carried out a day before planting. The rest of plots were planted with untreated seeds.

The plots were sprayed 10 days after planting (just after the seedlings showed up) with folidol E 605, Dipterex, Malathion and DDT-Lindane at the rate of 1, 2, 2.5 and 5 per thousand, respectively. Spraying was weekly repeated for 5 successive weeks.

Counts of infested plants were also weekly recorded just before spraying. Data are presented in Figures 1, 2 and 3. For statistical analysis, the percentage of infestations were transformed to angular degrees (FISHER, 1953).

RESULTS

(A) Moshtohor

The attack of *Agromyza* showed to be very severe to the young seedlings (a week after emergence or 17 days from planting), a fact which causes their death. About 70% of the control plants were severely infested at this stage (Fig. 1).

Seed dressing with systemic insecticides, i.e. Thimet 44-D and Disyston, decreased the percentage of infestation. In the first week after the emergence of young seedlings, the infestation was about 4% in either case. No phytotoxic effect on seedlings was noticed and the stand of plants especially those treated with Thimet

44-D was good. Comparing these results with the control (Fig. 1) it can be observed that the analysis of variance of angles shows a highly significant differences at both levels. Spraying with Dipterex was also superior to Folidol E 605, Malathion and DDT-Lindane (Fig. 1).

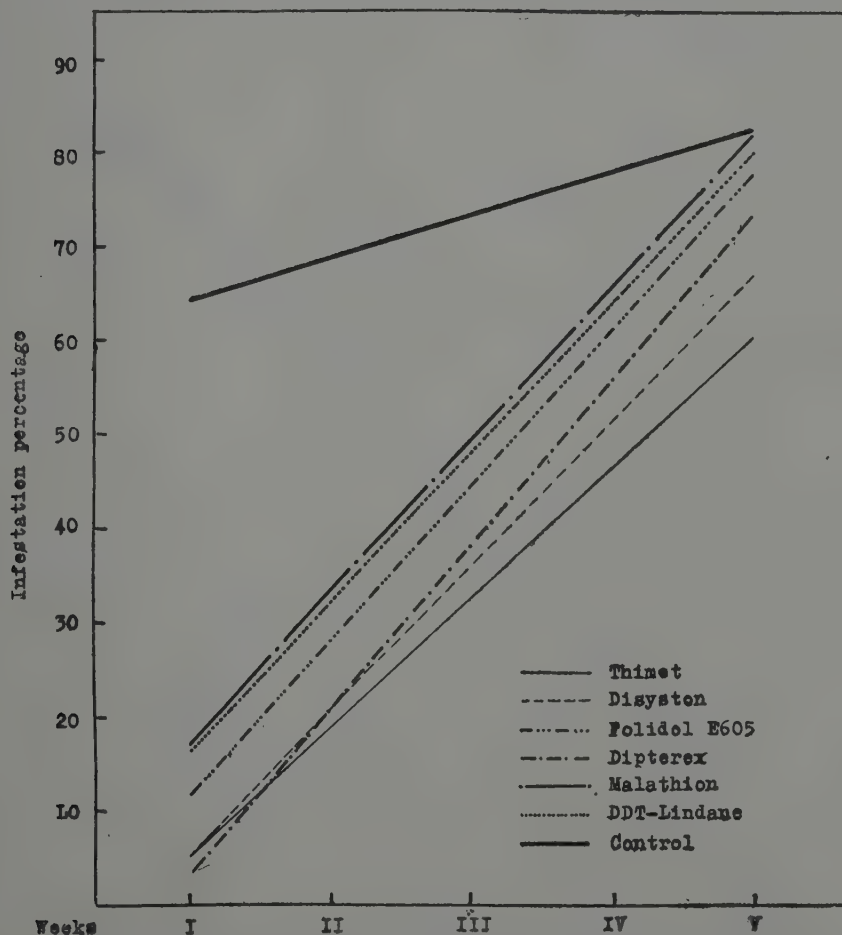


FIG. 1: Regression lines representing the infestation percentage of snap beans treated with different insecticides during the first five weeks at Moshtohor.

From these results, it can be concluded that Dipterex was leading followed by Thimet 44-D, Disyston and Folidol E 605. The differences between Dipterex and these chemicals were significant.

In the second week, after the emergence of seedlings, the percentage of infested plants increased pronouncely with the exception of the two first formulations. The analysis of variance of angles showed no significant differences between Thimet and Disyston. They gave significant results when compared with the other chemicals used.

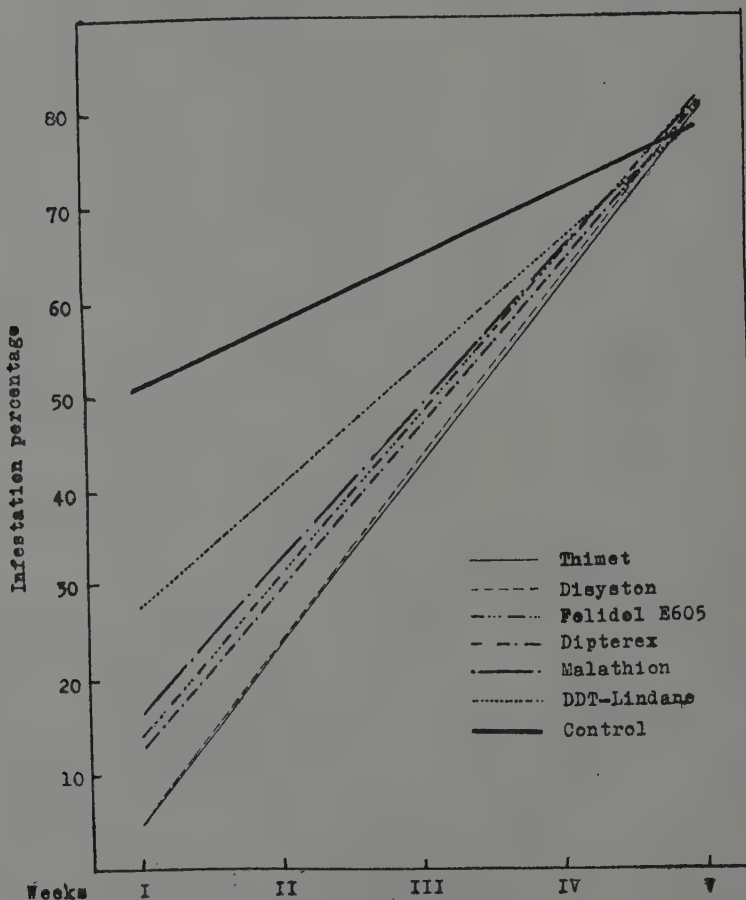


Fig. 2: Regression lines representing the infestation percentage of snap beans treated with different insecticides during the first five weeks at Kaha.

On comparing the results obtained in the second week with those of the first week (Fig. 1), insignificant differences were only found between Thimet 44-D and Disyston.

As plants grew old and produced more foliage, the percentage of infestation increased correspondingly. Thimet 44-D was always leading followed by Disyston.

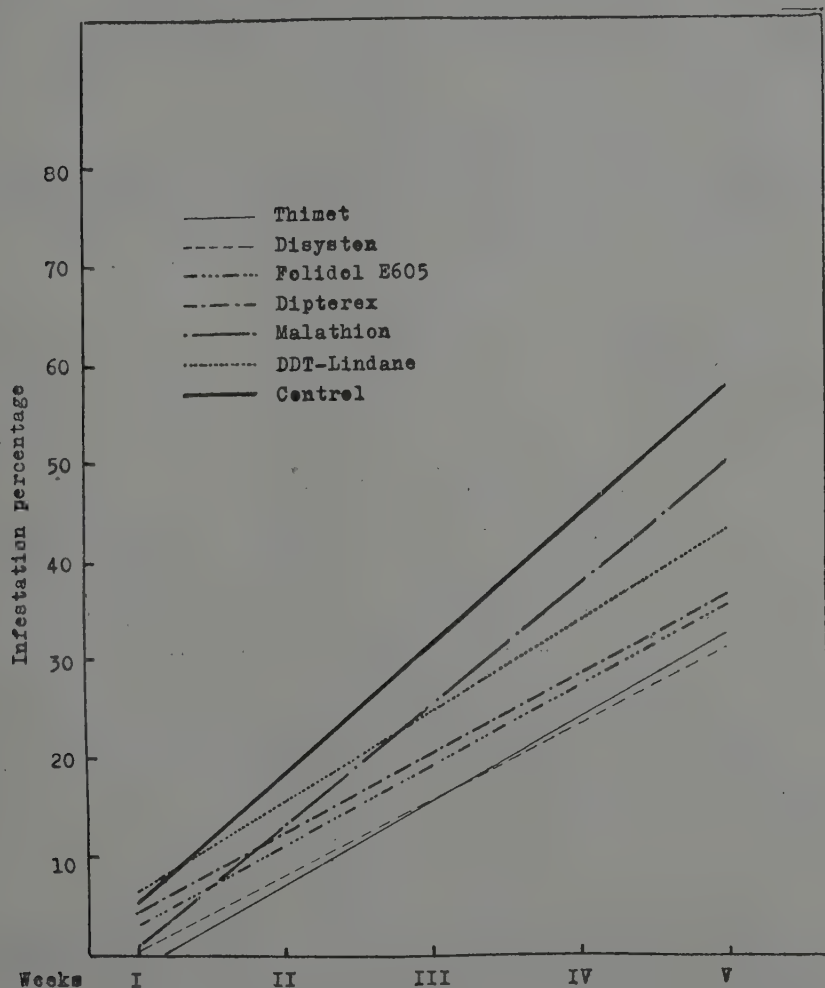


FIG. 3: Regression lines representing the infestation percentage of snap beans treated with different insecticides during the first five weeks at Anshas.

Thus, in the third week a rise in the percentage of infestation to 15 and 28% was observed in plots treated with Thimet 44-D and Disyston, respectively. Such

a rise could be attributed to the decrease of the poison concentration in the plant sap as compared to the size of the plant.

If 10% loss of plants is taken as a limit for the control of the larvae, Thimet 44-D and Disyston would prove quite effective to protect plants for 2 weeks from emergence of seedlings or 3 weeks from planting. Folidol E 605, Dipterex, Malathion and DDT-Lindane on the other hand proved to be much less effective (Fig. 1).

(B) Kaha

The results obtained at Kaha were nearly the same as those recorded at Moshtohor (Fig. 2). Thimet 44-D and Disyston were also leading in the first 2 weeks after the emergence of seedlings with highly significant differences from the rest of the formulations used.

(C) Anshas

The situation at Anshas was quite different from that at both Moshtohor and Kaha. No infestation in all treatments including the control plants was observed during the first week (Fig. 3).

This may be due to the fact that the population of insects was not large enough to cause any infestation at planting time. The drop of population is mostly due to the death of pupae in the hot sandy soil of Anshas during that period.

In the second week, the percentage of infestation was very low in all treatments, while it reached 17% in the control. The analysis of variance for angles shows significant differences between plants treated with Folidol E 605, Malathion and those treated with Thimet 44-D, Disyston, Dipterex and DDT-Lindane. Folidol E 605 and Malathion were leading followed by Thimet 44-D, Dipterex and Disyston.

As plants grew vegetatively the percentage of infestation increased. It can be concluded from the results obtained that Thimet 44-D and Disyston proved to be effective up to the third week from the emergence of seedlings, while the rest of chemicals gave poor control.

SUMMARY AND CONCLUSION

The heavy infestation of snap bean crop in Egypt, grown in the late summer, with *Agromyza phaseoli* Coq. calls for an effective control to overcome its dangerous effect.

Three locations were chosen at Moshtohor, Kaha and Anshas representing three different types of soils, i.e. loam, clay loam and sand, respectively.

Since the larvae feed on the internal tissues of the stem of young seedlings, 70% of the control plants were infested and died at the early stage at Moshtohor. Thus, any control used should start in a very early stage of growth.

The use of systemic insecticides such as Thimet 44-D and Disyston as seed dressing might prove the best measure to be applied. At Moshtohor these two chemicals proved to be effective at least 2 weeks after seedlings started to emerge above the soil or 25 days from planting.

As to the rest of the chemicals used, spraying was not very effective.

The situation at Kaha, was similar to that recorded at Moshtohor. Thimet 44-D and Disyston were leading the first two weeks after plants showed above the soil.

At Anshas, infestation could be hardly noticed in the first week even in the check plants. In the next week, infestation started but in small percentage and then increased with plant growth (Fig. 3). Still Thimet 44-D and Disyston proved to be very effective in the first three weeks after emergence.

The results can be summarized as follows:

(1) Thimet 44-D Disyston used as seed dressing at the rate of 2 and 8% were effective for 2 to 3 weeks after plants showed above the soil.

(2) Folidol E 605 Dipterex, Malathion and DDT-Lindane at the given concentrations were not effective against *Agromyza phaseoli* Coq.

REMARKS

No analysis of the fruit has been made as to its content of the systemics used.

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ON THE TAXONOMY OF *BRAULA COECA* NITZSCH

[*Diptera: Braulidae*]

(with 2 Text-Figures and 2 Tables)

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CONTENTS

I. Introduction. — II. Synonymy. — III. Geographical distribution. — IV. Material. — V. Morphology. — VI. Discussion. — VII. Summary. — VIII. References.

I. INTRODUCTION

This insect was first discovered by RÉAUMUR (1740) who briefly discussed the species and its relation to the honeybee. The genus as well as species were described by NITZSCH (1818) who named the insect *Braula coeca* and classified it, on account of the structure of the mouth-parts, with the Diptera associating it with the Pupipara.

Various discussions have been appeared in the last half of the nineteenth century regarding the exact classification of the species in the series of Diptera. Errors in NITZSCH's description of the antennae and thorax were corrected by EGGER (1853), thus removing any doubt as to the alliance of *Braula* to Diptera and he proposed for it the special family, Braulidac. It was also generally believed that *Braula coeca* was pupiparous but, according to MÜGGENBURG (1892), SKAIFE (1921) and ARNHART (1923a) it is oviparous; MÜGGENBURG described the mouth-parts and discovered the eyes of the supposedly blind insect; SKAIFE described its life-cycle and ARNHART found the mines and dried out larval skins. IMMS (1942), on the other hand, described the developmental stages of *Braula* in detail and accord-

ing to him the larva is inquiline living in a tubular burrow on the inner side of the capping of the honey cells.

It is also usually stated that there is but one species of *Braula*.

De Miranda RIBEIRO (1905) gave a half tone drawing of the species found in Brazil, in which the head appears to be relatively much narrower than in the European species. This, after careful examination, was denied by LIMA (cited by PHILLIPS, 1925).

SCHMITZ (1914) has described a new species, *Braula kohli*, from Congo on the African honeybee *Apis mellifica adansoni* Latreille, and called attention to the variation in the number of teeth in the tarsal combs; but, since he examined one individual male only, his data, of course, were inconclusive. SCHMITZ stated, in page 121 "Herr P. H. KOHL C. SS. C. brachte aus Africa eine von ihm bei Stanleyville (Congo) erbeutete Königin einer wilden Bienenart mit, an deren Flügelbasis eine *Braula* haftete". It is hoped, therefore, to re-investigate this interesting problem in order to be able to tell conclusively how many species of *Braula* do exist.

II. SYNONYMY

According to Phillips (1925) the synonymy of *Braula* is not complicated. COSTA gave it the name *Entomobsis*, evidently without knowing of the work of NITZSCH. BIGOT suggested that the name of the genus might more appropriately be MELITOMYIA, as better describing the habits of this insect. FABRICIUS erroneously placed the bee louse in the genus *Acarus*, based on the figure given by RÉAUMUR.

III. GEOGRAPHICAL DISTRIBUTION

According to PHILLIPS (1925) *Braula* occurs in Germany, Austria, Italy, France, England and in the Baltic region. It was also recorded in Mediterranean countries, in the island of Cyprus, in South Africa, Brazil, the Argentine Republic, Holland and Czechoslovakia. It is reported by ASSMUSS (1865) not to occur in northern, middle or southern Russia and by GALE as absent from Australia. PHILLIPS stated also that it has been introduced into the U.S. America from Italy.

IV. MATERIAL

The insects used in this study were obtained from apiaries of the Egyptian honeybee *Apis mellifica fasciata* in the neighbourhood of Cairo.

V. MORPHOLOGY

The insect is reddish-brown in colour. The males being somewhat smaller on the average than the females (Table I). The whole body is covered with numerous stiff spine-like hairs. On the head, the hairs are especially numerous on the dorsal side with the exception of the clypeus.

TABLE I

Dimensions of Braula coeca Nitzsch from Egypt.

Sex	Mean width of head in mm.	Mean width of abdomen in mm.	Mean length of body in mm.
Female	0.667	1.056	1.501
Male	0.645	1.001	1.446

The head is almost flattened and is oriented vertically on the thorax, bringing the mouth-parts toward the ventral surface of the insect. The antennae have a peculiar structure and are articulated in a deep fossa on each side of the head. Eye rudiments are present just above the antennae as pale spots on the cuticle surrounded by more darkly pigmented chitinous rings, but there are no ocelli.

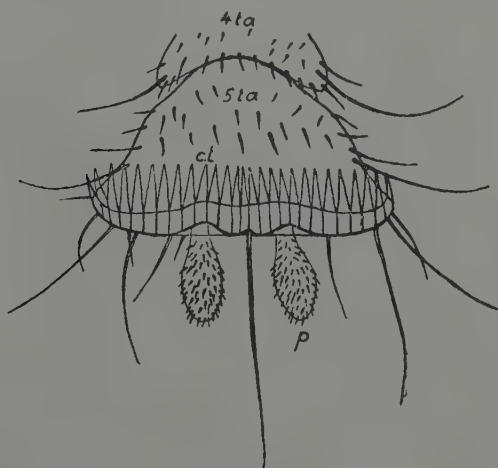


FIG. 1: Last tarsal joint of Egyptian *Braula coeca* Nitzsch with 27 comb-teeth (c.t.); 4ta, fourth tarsal joint; 5ta, fifth tarsal joint; p, pulvillus.

The thorax is discoid, very short and is inserted throughout its width on the abdomen. There is no trace of either wings or halteres. The legs are long in propor-

tion to the length of the body but they are not equal in length as it has been mentioned by PHILLIPS (1925); the foreleg is shorter than the mid- and hind-leg and the latter is the longest one. The tarsus is 5-jointed. Each last tarsal joint carries two pear-shaped pulvilli of delicate structure and covered with fine hairs. The terminal tarsal joint of each leg is provided also with a special chitinous comb-like structure, divided in the middle with a variable number (11-15) of teeth or modified claws on each side of the median line (Fig. 1). These combs allow *Braula* to attach itself firmly to the branched hairs of its host. They are quite indispensable for an animal living on a rapidly moving and flying insect like the honeybee.

The abdomen has five dorsally visible segments and occupies about three quarters of the whole length of the body. It is more or less cylindrical in general shape, and tapering slightly to the posterior end.

VI. DISCUSSION

When SCHMITZ (1914) declared the existence of an Africa *Braula* species "*Braula kohli*" he supported his view by the following observations:

Form of the abdomen: According to SCHMITZ the abdomen of "*Braula kohli*" is elliptical in shape in comparison with that of *Braula coeca* Nitzsch which is almost circular. Figure 2 shows clearly that the abdomens of males *Braula coeca* Nitzsch. (B), the Brazilian *Braula coeca* (D) and the Egyptian *Braula coeca* (F) incline also

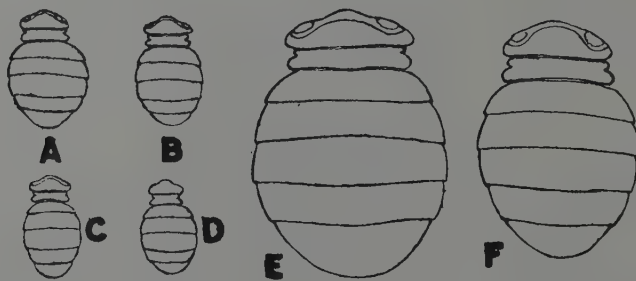


FIG. 2: A, Female *Braula coeca* Nitzsch; B, Male *Braula coeca* Nitzsch; C, Male *Braula kohli* Schmitz; D, *Braula coeca* from Brazil; E, Female Egyptian *Braula coeca*; F, Male Egyptian *Braula coeca*.

to be somewhat elliptical in form. A change in the form of the body, on the other hand, is also quite possible through extension of the abdominal segments (e.g. pressure of microscope glass cover) or through contraction (e.g. dessiccation).

Number of comb-teeth: SCHMITZ claimed that the number of comb-teeth present on the terminal tarsal joint can be considered as the decisive character to

differentiate between the two or three species of *Braula*. Reviewing the literature it was found that *B. kohli* carries 24 or 25 teeth (SCHMITZ, 1914), while *B. coeca* has 30-32 teeth (EGGER, 1853), 29 teeth (MEINERT, 1890), 32 teeth (LOS, 1902), 24 teeth (BÖRNER, 1908) and 30-32 teeth (MASSONNAT, 1909). De Miranda RIBEIRO (1905) counted 22-24 teeth by the Brazilian *B. coeca*. SCHMITZ, in his conclusion, dropped the number (24 teeth) given by BÖRNER pretending that his figure was schematic. The number of comb-teeth in the fore-, mid- and hind-legs of both right and left sides in 35 individuals of Egyptian *Braula coeca* were, on the other hand, counted and the results obtained are given in Table II. These results show that the average number of comb-teeth is 26.6 with 23 and 30 as minimum and maximum, respectively. The number of teeth varies also from leg to leg, from side to side, from individual to individual and from sex to sex.

TABLE II
Number of comb-teeth in 35 individuals of *Braula coeca* Nitzsch.

	Number of comb-teeth						Sex		Number of comb-teeth						Sex
	Fore-legs		Mid-legs		Hind-legs				Fore-legs		Mid-legs		Hind-legs		
	R.	L.	R.	L.	R.	L.			R.	L.	R.	L.	R.	L.	
1	25	25	25	26	25	25	Female	18	23	—	24	24	24	25	Female
2	29	26	28	27	28	27	„	19	26	26	28	26	26	26	„
3	28	27	27	27	27	27	„	20	25	28	24	26	27	28	„
4	28	26	28	26	25	28	„	21	27	28	28	27	27	28	„
5	29	29	29	28	28	28	„	22	26	24	25	25	24	—	„
6	27	28	28	26	27	28	Male	23	28	28	28	27	29	28	„
7	25	24	25	26	25	24	Female	24	26	26	25	27	26	26	„
8	28	27	27	28	27	26	Male	25	26	27	25	27	28	28	Male
9	30	28	28	28	28	29	Female	26	27	28	27	27	27	26	Female
10	26	28	28	28	—	27	„	27	25	25	26	27	25	25	Male
11	27	27	27	27	27	27	„	28	28	26	28	25	27	26	Female
12	27	29	26	26	28	26	„	29	26	25	26	26	25	25	„
13	26	27	26	26	24	26	„	30	27	25	—	27	26	28	„
14	26	24	26	25	26	25	„	31	26	27	25	25	24	25	„
15	28	28	28	28	28	28	„	32	25	27	28	28	26	27	„
16	26	24	25	24	26	26	„	33	24	24	24	24	24	25	Male
17	28	27	26	27	26	26	„	34	29	28	28	27	28	29	Female
								35	27	28	26	27	27	27	Male

Mean

26.6

Colour: SCHMITZ stated that the colour of *B. kohli* appears, in alcohol, paler than that of *B. coeca*; the antennae are also whitish, while those of *B. coeca* are honey-yellow. However, colour variation is of little importance since the newly developed *Braula* are yellowish white and their colour darkens gradually until they attain their final reddish-brown colouration.

Variations in mouth-parts, head and thorax are not existing in *B. coeca* Nitzsch, *B. kohli*, Brazilian *B. coeca* or Egyptian *B. coeca*. From the biological point of view, on the other hand, both *Braula coeca* and *Braula kohli* in Europe, Brazil or Africa are quite similar since they are oviparous, they parasitise honeybees only and show a special preference to the queens.

VII. SUMMARY

The author is of the opinion that the honeybee louse existing in the Egyptian apiaries is *Braula coeca* Nitzsch. The announcement of the presence of an African *Braula* species with twenty four comb-teeth disaccords completely with our results.

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THE CULICINE MOSQUITOES OF THE NORTHERN REGION OF THE UNITED ARAB REPUBLIC

[*Diptera: Culicidae*]

(with 1 Map and 3 Tables)

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The present author (ABDEL-MALEK, 1958) gave a detailed account of the *Anopheline* mosquitoes of northern Syria. This paper deals with a collection of Culicine mosquito larvae made by the author during 1954 in northern Syria. The area surveyed began from Homs and extended north-west to include the Governorates of Hama, Aleppo and Lattakia up to the Turkish frontiers to the north. The survey extended also north-east to include the Governorates of Euphrates and Jesireh up to the frontiers of Iraq to the east and the Turkish frontiers to the north.

PREVIOUS RECORDS

Prior to the making of this collection, only fourteen Culicine species had been recorded in the literature from Syria, by PARR (1943) who encountered the following species: *Uranotaenia unguiculata* Edw., *Theobaldia subochrea* Edw., *Theobaldia annulata* Schr., *Theobaldia longiareolata* Macq., *Taeniorhynchus richardii* Fic., *Taeniorhynchus buxtoni* Edw., *Aedes aegypti* Linn., *Culex hortensis* Fic., *Culex laticinctus* Edw., *Culex mimeticus* Noe., *Culex molestus* Forsk., *Culex theileri* Theo., *Culex tritaeniorhynchus* Giles, and *Culex univittatus* Theo.

The list given in this paper contains twenty species eight of which are recorded for the first time from the northern region of the United Arab Republic, namely:

Aedes caspius Pallas, *Aedes mariae* Sergent, *Culex decens* Theo., *Culex fatigans* Wied., *Culex mattinglyi* Knight, *Culex pipiens* Linn., *Culex pusillus* (Macq.) Storey and *Culex thalassius* Theo. The author did not encounter the two *Taeniorhynchus* species recorded by PARR (1943). Table I gives the distribution of the species collected and shows that at least five species are the most common in the area surveyed. These are *Culex univittatus*, *Culex tritaeniorhynchus*, *Culex theileri*, *Culex mimeticus* and *Culex laticinctus*.



Map of the northern region of the United Arab Republic.

Table II shows the distribution of the species encountered according to the breeding places of the larvae. The number given under each breeding place represents the number of times the species was taken from that habitat. It will be seen from this Table that swamps, temporary pools and irrigation canals make favourite breeding places for most of the species encountered, with the other breeding sites coming next in importance.

TABLE I
Distribution of the Culicine collected from the northern region of the United Arab Republic.

Species	Governorates and Cases											
	Homs		Hama	Latakia	Aleppo	Euphrat.		Jesireh				
	Kous-seir	Rastan	Hama	Tell-Kalakh	Jisr-el-chaghour	Deir-el-Zor	Deirik	Kami-chli	Tell-Tamer	Amouda	Ras-el-Ain	Hassat-che
<i>U. unguiculata</i>	+				+		+	+		+	+	
<i>T. annulata</i>	+											
<i>T. longiareolata</i>	+											
<i>T. subochrea</i>												
<i>A. aegypti</i>												
<i>A. caspius</i>					+							
<i>A. mariae</i>												
<i>C. decens</i>					+	+		+		+	+	
<i>C. fatigans</i>												
<i>C. hortensis</i>					+							
<i>C. laticinctus</i>	+				+	+	+	+	+	+	+	+
<i>C. mattinglyi</i>				+								
<i>C. mimeticus</i>	+											
<i>C. molestus</i>	+		+	+		+	+	+	+	+	+	+
<i>C. pipiens</i>					+							
<i>C. pusillus</i>												
<i>C. thalassius</i>					+	+	+	+	+	+	+	+
<i>C. theileri</i>					+	+	+	+	+	+	+	+
<i>C. tritaeniorhynchus</i>	+			+	+	+	+	+	+	+	+	+
<i>C. univittatus</i>				+	+	+	+	+	+	+	+	+

TABLE II

Habitat distribution of the larvae of Culicine mosquitoes encountered in the northern region of the United Arab Republic

Species	Swamp	Irrigation canal	Spring	River bank	Well	Temporary pool	Hoof prints
<i>U. unguiculata</i>	2		1				1
<i>T. annulata</i>	1	2					
<i>T. longiareolata</i>		1				1	
<i>T. subochrea</i>		1			1		
<i>A. aegypti</i>							1
<i>A. caspius</i>	1						
<i>A. mariae</i>				1			
<i>C. decens</i>	2		1			1	
<i>C. fatigans</i>							1
<i>C. hortensis</i>				1			1
<i>C. laticinctus</i>	8	3	1			2	1
<i>C. mattinglyi</i>	3						1
<i>C. mimeticus</i>	6	1	1	1		5	1
<i>C. molestus</i>	1	2			1		
<i>C. pipiens</i>	3	1				1	
<i>C. pusillus</i>	2					1	
<i>C. thalassius</i>	2						
<i>C. theileri</i>	4	2	3			4	
<i>C. tritaeniorhynchus</i>	6		1			1	1
<i>C. univittatus</i>	8		1			2	1

Table III shows the associations with different other of the larvae of Culicine species encountered. The figures in roman represent the number of times each species is taken together with the other species. The figures in italics represent the number of times each species is found alone.

BIOLOGY AND DISTRIBUTION

Uranotaenia unguiculata Edwards

PARR (1943) collected a single larva of this species from a small clay pit at Ammiq swamp in October 1942. That was the only incidence the species had been taken from Syria.

Larvae were collected by the author, in October, from four different places in the Governorate of Jesireh, as follows:

(1) The village Babassi (Kamichli casa) from a spring with floating algae, in association with larvae of *C. tritaeniorhynchus*, *C. mimeticus*, *C. univittatus*, *C. decens* and *C. theileri*.

TABLE III

The association with each other of the larvae of the different species of Culicines encountered in the northern region of the United Arab Republic.

SPECIES	<i>U. unguiculata</i>	<i>T. annulata</i>	<i>T. longiareolata</i>	<i>T. subochrea</i>	<i>A. aegypti</i>	<i>A. caspius</i>	<i>A. mariae</i>	<i>C. decens</i>	<i>C. fatigans</i>	<i>C. hortensis</i>	<i>C. laticinctus</i>	<i>C. mattinglyi</i>	<i>C. mimeticus</i>	<i>C. molestus</i>	<i>C. pipiens</i>	<i>C. pusillus</i>	<i>C. thalassius</i>	<i>C. theileri</i>	<i>C. tritaeniorhynchus</i>	<i>C. univittatus</i>
<i>U. unguiculata</i>								1		1	2	1	3		1			3	1	3
<i>T. annulata</i>				1																
<i>T. longiareolata</i>			1																	
<i>T. subochrea</i>				1																
<i>A. aegypti</i>																				
<i>A. caspius</i>																				
<i>A. mariae</i>							1													
<i>C. decens</i>		1																		
<i>C. fatigans</i>									1											
<i>C. hortensis</i>																				
<i>C. laticinctus</i>		2	1			1		3		1	1	2	8	1	3	2	2	7	6	7
<i>C. mattinglyi</i>		1			1						2		3	1		1		1	3	3
<i>C. mimeticus</i>		3	1					3		1	8	3	1	1	2	3		10	5	5
<i>C. molestus</i>											1	1		1					1	1
<i>C. pipiens</i>	1	1						1			3		2	1	1		1	3	2	1
<i>C. pusillus</i>								1			2	1	3				2	1	1	1
<i>C. thalassius</i>								1			2				1				1	2
<i>C. theileri</i>		3	2					3			6	1	10		3	2		1	4	4
<i>C. tritaeniorhynchus</i>		4			1			3		1	6	3	5	1	2	1	1	4	8	8
<i>C. univittatus</i>		3			1			3		1	7	2	6	1	1	1	2	4	8	2

(2) The village Khanik (Amouda casa) from a swamp supplied from a spring with emergent, submergent and floating vegetation, in association with larvae of *C. mimeticus*, *C. univittatus*, *C. theileri*, *C. mattinglyi*, *C. tritaeniorhynchus*, and *C. laticinctus*.

(3) Ras-el-Ain, from a large swamp supplied from a spring with submergent vegetation, in association with larvae of *C. pipiens*, *C. tritaeniorhynchus*, *C. mimeticus* and *C. theileri*.

(4) The village Ain-Diwar (Deirik casa) from hoof prints full of water with green algal floatage, in association with larvae of *C. univittatus*, *C. hortensis*, *C. tritaeniorhynchus* and *C. laticinctus*.

DISTRIBUTION: Egypt (STOREY, 1918; KIRKPATRICK, 1925, ABDEL-MALEK, 1956); Syria and Lebanon (PARR, 1943); Iraq (KHATTAT, 1955); Palestine (BARRAUD, 1921); Macedonia (WATERSTON, 1918).

***Theobaldia* (*Theobaldia*) *annulata* Schrank**

PARR (1943) found larvae in Syria, abundant at all times of the year, in swamps, small seepage pools and rain-water cisterns.

Larvae were collected in numbers by the author, in May, from irrigation canals with emergent vegetation and algal growth, in two villages in Homs, namely, Kafr-Abdi and Moudane (Kousseir casa). In Kafr-Abdi, the larvae were in association with those of *Theobaldia subochrea*. In Moudane, they were in association with larvae of *Culex theileri*. Larvae were also taken, in the same month, from a swamp in the village Zarra (Kousseir casa) near Homs lake, in association with those of *C. laticinctus*, *C. mimeticus*, *C. pipiens* and *C. theileri*.

DISTRIBUTION: Palestine (BARRAUD, 1921); Syria (PARR, 1943); Iran (GHAFARY, 1954); Lebanon (BARRAUD, 1921); Algeria (EDWARDS, 1911); Macedonia (Waterston, 1918).

***Theobaldia* (*Allotheobaldia*) *longiareolate* Macquart**

Reported by PARR from Syria as common in coastal towns and villages throughout the spring and autumn months, breeding in rock pools, march pools cisterns, pits and large swamps. BEDFORD (1928), in South Africa, found it to breed in pools, barrels, dipping tanks and in a tarpaulin rain water.

Larvae were collected by the author, in September, from a temporary rock pool with stagnant water, in the village Douair-el-Akrad (Jisr-el-Chaghour casa, Aleppo). Larvae were also taken in May, from an irrigation canal with emergent vegetation and algal floatage, in the village Tell-Nebi-Mend (Kousseir casa, Homs), in association with larvae of *Culex pipiens*.

DISTRIBUTION: Egypt (STOREY, 1918); Northern Sinai (ABDEL-MALEK, 1956), Siwa Oasis (GAD, 1956); Lebanon (BARRAUD, 1921); Syria (PARR, 1943); Iran (GHAFARY, 1954); Iraq (BARRAUD, 1920); Arabia (MATTINGLY and KNIGHT, 1956);

Yemen (KNIGHT, 1953B); Palestine (BARRAUD, 1921); Macedonia (WATERSTON, 1918).

***Theobaldia (Theobaldia) subochrea* Edwards**

It has been taken as adults only by PARR at Ammiq swamp, in July 1942. That was the only occasion in which it has ever been recorded from Syria. MARSHALL (1938) found larvae not only in ditches and ponds, in both open and shaded situations but also in garden and farmyard tanks. Like *T. annulata*, *T. subochrea* breeds both in non-salty water and in water of varying degrees of salinity up to at least 0.36 times that of sea water.

Larvae were collected by the author, in May from a well in the village Tell-Bisseh (Rastan casa, Homs). Larvae were also collected from an irrigation canal with emergent vegetation and algal growth, in the village Kafr-Abdi (Kous-seir casa, Homs), in association with those of *T. annulata*.

DISTRIBUTION: Lebanon and Syria (PARR, 1943); Palestine, Iraq, Iran and Macedonia (EDWARDS, 1921).

***Aedes (Stegomyia) aegypti* Linn.**

Recorded from Syria by PARR (1943). He stated that it was common in towns and villages throughout the coastal zone but almost entirely absent from inland areas. Breeding occurred in water butts, rain-water cisterns, small pools and in shallow flower pots during the months June to October.

Larvae were collected by the author, in October, from hoof prints full of water with green algal floatage on a river bank in the village Maachouq (Kamichli casa, Jesireh), in association with those of *Culex mimeticus* and *Culex mattinglyi*.

DISTRIBUTION: Egypt (GOUGH, 1914); Lebanon and Syria (PARR, 1943); Iran (GHAFFARY, 1954); Arabia (MATTIGLY and KNIGHT, 1956); Yemen (KNIGHT, 1953B).

***Aedes (Ochlerotatus) caspius* Pallas**

This is the first record from the northern region of the United Arab Republic.

Larvae were collected once, in September, from a swamp with emergent vegetation in the village Ziara (Jisr-el-Chaghour casa, Aleppo), in association with larvae of *C. laticinctus*, *C. univittatus* and *C. tritaeniorhynchus*.

DISTRIBUTION: Egypt (BARRAUD, 1921); Iraq, Iran, Palestine and Arabia.

***Aedes (Ochlerotatus) mariae* Sergent**

Not previously recorded from the northern region of the United Arab Republic.

Larvae of *Aedes mariae* were taken alone in October, from a river bank with fairly fast-running clear water, in the village Giennatamer Gharbi (Ras-el-Ain casa, Jesireh).

DISTRIBUTION: Lebanon (PARR, 1943); Palestine (BARRAUD, 1921); Algerian coast (SERGENT, 1903); Iran (GHAFFARY, 1954).

Culex (Culex) decens Theobald

This is the first record of this species from Syria.

Larvae were taken four times during September and October, from swamps, a spring and a temporary pool.

From swamps, larvae occurred in two villages in Jisr-el-Chaghour casa, Aleppo, namely El-Rassif and Ziara, in association with those of *C. thalassius*, *C. laticinctus*, *C. pipiens*, *C. tritaeniorhynchus* and *C. univittatus*. In another swamp in the village Tell-Hamdoun (Amouda casa, Jesireh) larvae were taken in association with those of *C. laticinctus*, *C. mimeticus*, *C. theileri* and *C. pusillus*.

Larvae were also taken from a spring seepage with algal floatage, in the village Babassi (Kamichli casa, Jesireh), in association with those of *C. mimeticus*, *C. theileri*, *C. univittatus*, *C. tritaeniorhynchus* and *U. unguiculata*.

From a temporary pool on the side of an irrigation canal supplied from a sakiya on the Khabour river in the village Souar (Deir-el-Zor casa, Euphrates), larvae were taken in association with those of *C. mimeticus*, *C. laticinctus*, *C. theileri*, *C. univittatus* and *C. tritaeniorhynchus*.

DISTRIBUTION: Egypt (STOREY, 1918); Arabia (MATTINGLY and KNIGHT, 1956); Yemen (KNIGHT, 1953B); Sierra Leone, Nigeria, Sudan, Uganda and Transvaal (EDWARDS, 1911).

Culex (Culex) fatigans Weid.

This is the first record of the occurrence of this species in Syria.

Larvae were taken, in September, alone from hoof prints full of clear water and present on a hill in the forested village named Ichtabiraq (Jisr-el-Chaghour casa, Aleppo).

DISTRIBUTION: Egypt and Sudan (THEOBALD, 1904); Iraq (BARRAUD, 1920); Arabia (MATTINGLY and KNIGHT, 1956); West Africa (INGRAM and MACFIE, 1917).

Culex (Culex) hortensis Ficaldi

The first report of this species from Syria was given by BARRAUD (1921) who found the larvae breeding in a pool in Damascus. PARR (1943) found larvae almost everywhere along the Lebanese coast from Beirut southwards in the spring months, breeding in rain-water cisterns and open unshaded shallow pools containing dense grass vegetation.

Larvae were collected, in October, from two villages in Deirik casa, Jesireh, namely; Tell Khanzir Kebir and Ain Diwar. In the former village, the larvae were taken from the bank of a shallow river with emergent vegetation and floating green

algae, in association with larval of *C. mimeticus*. In the latter village, larvae of *C. hortensis* were taken, from hoof prints full of water with algal floatage and supplied from a spring, in association with those of *C. laticinctus*, *C. tritaeniorhynchus*, *C. univittatus* and *U. unguiculata*.

DISTRIBUTION: Syria and Palestine (BARRAUD, 1921); Lebanon (PARR, 1943)

***Culex (Culex) laticinctus* Edw.**

Found by PARR (1943), in two Syrian localities, namely Afrine and Ammiq. A single larva was taken from a water cistern in association with those of *C. tritaeniorhynchus*.

Culex laticinctus is regarded the most common Culicine present in the northern region of the United Arab Republic. Larvae were collected from a variety of breeding places including swamps, irrigation canals, a spring, temporary pools and hoof prints.

From swamps, larvae were taken, in September, in the following villages in Jisr-el-Chaghour casa, Aleppo: (1) Ziara, in association with larvae of *Aedes caspius*, *C. tritaeniorhynchus* and *C. univittatus*; (2) El-Rassif, in association with larvae of *C. decens*, *C. thalassius*, *C. pipiens*, *C. tritaeniorhynchus* and *C. univittatus*; (3) Kherbet-el-Naous, in association with larvae of *C. thalassius* and *C. univittatus*; and (4) Qarqour.

In other parts of the country, larvae were collected also from swamps in the following villages: (1) Zarra (Kousseir casa, Homs) in May, in association with larvae of *C. mimeticus*, *C. pipiens*, *C. theileri* and *T. annulata*; (2) Souediye (Deirik casa, Jesireh) in October, in association with larvae of *C. mimeticus*, *C. mattinglyi*, *C. pusillus*, *C. tritaeniorhynchus* and *C. univittatus*; (3) Tell-Hamdoun (Amouda casa, Jesireh) in October, in association with larvae of *C. decens*, *C. mimeticus*, *C. pusillus* and *C. theileri*; (4) Mailobiye (Hassatche casa, Jesireh) in October, in association with larvae of *C. mimeticus* and *C. theileri*.

From irrigation canals with emergent vegetation and algal floatage, larvae were taken in the following villages: (1) Rabbe (Kousseir casa, Homs) in May, in association with larvae of *C. mimeticus*; (2) Moudane (Kousseir casa, Homs) in June, in association with larvae of *C. molestus*; (3) Tell-Massas (Tell-Tamer, casa, Jesireh) in October, in association with larvae of *C. pipiens* and *C. theileri*.

Larvae were taken also from a spring, in October, in the village Khanik (Amouda casa, Jesireh), in association with larvae of *C. mimeticus*, *C. mattinglyi*, *C. theileri*, *C. tritaeniorhynchus*, *C. univittatus* and *U. unguiculata*.

Larvae were again found, in October, in temporary pools on the side of irrigation canals in the following two villages: (1) Aarbouch (Tell-Tamer casa, Euphrates), in association with larvae of *C. mimeticus* and *C. theileri*; and (2) Souar (Deir-el-Zor casa, Euphrates), in association with larvae of *C. decens*, *C. mimeticus*, *C. theileri*, *C. tritaeniorhynchus* and *C. univittatus*.

Larvae were taken once, in October, from hoof-prints with water supply from a spring in the village Ain Diwar (Deirik casa, Jesireh), in association with those of *C. hortensis*, *C. univittatus*, *C. tritaeniorhynchus* and *U. unguiculata*.

DISTRIBUTION: Egypt (BARRAUD, 1921); Syria (PARR, 1943); Lebanon (BARRAUD, 1921); Iran; Arabia and Yemen.

Culex (Culex) mattinglyi Knight

This is the first record of this species from the northern region of the United Arab Republic.

Larvae were taken four times, once from hoof prints and three times from swamps.

From swamps, larvae were collected in the following villages: (1) Aida (Tell-Kalakh casa, Lattakia) in June, in association with larvae of *C. molestus*, *C. tritaeniorhynchus* and *C. univittatus*; (2) Souediye (Deirik casa, Jesireh) in October, in association with larvae of *C. laticinctus*, *C. mimeticus*, *C. pusillus*, *C. tritaeniorhynchus*, and *C. univittatus*; and (3) Khanik (Amouda casa, Jesireh) in October, in association with larvae of *C. laticinctus*, *C. mimeticus*, *C. theileri*, *C. tritaeniorhynchus*, *C. univittatus* and *U. unguiculata*.

Larvae were collected once from hoof prints on a river bank with floating algae, in the village Maachouq (Kamichli casa, Jesireh), in association with larvae of *C. mimeticus* and *A. aegypti*.

DISTRIBUTION: Yemen (KNIGHT, 1953A) and Arabia (MATTINGLY and KNIGHT, 1956).

Culex (Culex) mimeticus Noe

Previously reported from Syria and Lebanon by PARR (1943) where it was common throughout the summer in coastal and inland areas. According to PARR, *C. mimeticus* breeds in rocky rain water pools in the dried-up beds of streams and rivers.

It was found to be one of the most common species of Culicine collected from the northern region of the United Arab Republic. Larvae were taken from a variety of breeding places including swamps, temporary pools, irrigation canals, springs, river banks and hoof prints.

From swamps, larvae were taken in October, in the following villages of the Jesireh Governorate: (1) Babassi (Kamichli casa) in association with larvae of *C. decens*, *C. theileri*, *C. tritaeniorhynchus*, *C. univittatus* and *U. unguiculata*; (2) Souediye (Deirik casa) in association with larvae of *C. laticinctus*, *C. pusillus*, *C. mattinglyi*, *C. tritaeniorhynchus*, *C. univittatus*; (3) Tell-Hamdoun (Amouda casa) in association with larvae of *C. decens*, *C. laticinctus*, *C. pusillus* and *C. theileri*; (4) Khanik (Amouda, casa) in association with larvae of *C. mattinglyi*, *C. laticinctus*, *C. theileri*, *C. univittatus*, *C. tritaeniorhynchus* and *U. unguiculata*; (5) Mailobiye

(Hassatche casa) in association with larvae of *C. laticinctus* and *C. theileri*; and (6) Ras-el-Ain, in association with larvae of *C. pipiens*, *C. theileri* and *C. unguiculata*. In May, larvae were also collected from a swamp present in the village Zarra (Kousseir casa, Homs), in association with larvae of *C. laticinctus*, *C. pipiens*, *C. theileri* and *T. annulata*.

From temporary pools, larvae were taken during October, in the following village in Jesireh: (1) Tell-Aarade (Ras-el-Ain casa) in association with larvae of *C. pusillus* and *C. theileri*; (2) Himo (Kamichli casa); (3) Arbouch (Hassatche casa), in association with larvae of *C. laticinctus* and *C. theileri*; (4) Souar (Deir-el-Zor casa), in association with larvae of *C. decens*, *C. laticinctus*, *C. theileri*, *C. tritaeniorhynchus* and *C. univittatus*; and (5) Quiri Ziara (Deirik casa), in association with larvae of *C. theileri* and *C. univittatus*.

Larvae were collected once, in October, from a shallow river bank with emergent vegetation and algal floatage, in the village Tell-Khanzir Kebir (Deirik casa) in association with those of *C. hortensis*.

They were also obtained in October from an irrigation canal in the village Rabbe (Kousseir casa, Homs), in association with those of *C. laticinctus*.

From hoof prints on a river bank in the village Maachouq (Kamichli casa, Jesireh), larvae were collected, in October, in association with those of *C. mattinglyi* and *A. aegypti*, and were also taken in October, from a spring with algal floatage, in the village Babassi (Kamichli casa, Jesireh), in association with larvae of *C. decens*, *C. theileri*, *C. tritaeniorhynchus*, *C. univittatus* and *U. unguiculata*.

DISTRIBUTION: Lebanon; Syria; Palestine; Iran; and Macedonia.

***Culex (Culex) molestus* Forskal**

Reported by PARR (1943) as a domestic species in Syria, although little is known of its habitats there.

Larvae were taken from a well, a swamp and irrigation canals in four villages at: (1) El-Rabie (Hama) in April, from a well; (2) Arida (Tell-Kalakh casa, Lattakia) in June, from a swamp with emergent and floating vegetation, in association with larvae of *C. mattinglyi*, *C. tritaeniorhynchus* and *C. univittatus*; and (3) Tell-Nebi-Mend and Moudane (Kousseir casa, Homs), in May and June, respectively, from irrigation canals, in association with larvae of *T. longiareolata* in the former village and *C. laticinctus* in the latter village.

DISTRIBUTION: Egypt (KNIGHT and ABDEL-MALEK, 1951); Syria; Lebanon and Arabia.

***Culex (Culex) pipiens* Linn.**

A species which has not been recorded previously from the northern region of the United Arab Republic.

From swamps, larvae were taken in the following villages: (1) El-Rassif (Jisr-el-Chaghour casa, Aleppo) in September, in association with those of *C. decens*, *C. laticinctus*, *C. thalassius*, *C. tritaeniorhynchus*, and *C. univittatus*; (2) El-Zarra (Kousseir casa, Homs) in May, in association with those of *C. laticinctus*, *C. theileri*, *C. mimeticus* and *T. annulata*; (3) Ras-el-Ain (Jesireh) in October, in association with those of *C. mimeticus*, *C. theileri*, *C. tritaeniorhynchus* and *U. unguiculata*. Individuals were taken in November 1953, from a temporary pool with floating algae, in the village Rastan (Homs). From an irrigation canal supplied from the river Khabour in the village Tell-Massas (Tell-Tamer casa, Jesireh), larvae were collected, in October, in association with those of *C. laticinctus* and *C. theileri*.

DISTRIBUTION: Egypt (BECKER, 1903); Iraq (KHATTAT, 1955); Lebanon (BARRAUD, 1921); Yemen (KNIGHT, 1953), Arabia (MATTINGLY and KNIGHT, 1956) and Macedonia (WATERSTON, 1918).

***Culex* (Barraudius) pusillus Macquart**

This is the first record of this species from the northern region of the United Arab Republic.

Larvae of *C. pusillus* were taken three times from different places in the area surveyed. From swamps originating from springs, larvae obtained, were in October, from two villages in Jesireh, namely, Souediye (Deirik casa) and Tell-Hamdoun (Amouda casa). In the former village, the larvae were found in association with those of *C. laticinctus*, *C. mimeticus*, *C. mattinglyi*, *C. tritaeniorhynchus* and *C. univittatus*. In the latter village, larvae were associated with those of *C. decens*, *C. laticinctus*, *C. mimeticus* and *C. theileri*.

Larvae were also collected in October, from a side temporary pool from river Zerkani in the village Tell-Aarade (Ras-el-Ain casa, Jesireh), in association with those of *C. mimeticus* and *C. theileri*.

DISTRIBUTION: Egypt (STOREY, 1918); Iraq (BARRAUD, 1920); Arabia (MATTINGLY and KNIGHT, 1956).

***Culex* (Culex) thalassius Theobald**

This is the first record of this species from the northern region of the United Arab Republic.

Already recorded from Accra in West Africa by INGRAM and MACFIE (1917) who found the larvae flourishing in a variety of situations, such as a brackish lagoon, crab-holes, foul-smelling water holes, earth drains, pools of various sorts, an iron pot and a spring.

The author collected larvae, in September, from swamps with emergent and floating vegetation in two villages in the Ghab, namely, El-Rassif and Kherbet-el-Naous (Jisr-el-Chaghour casa, Aleppo). In the former village, they were found in

association with those of *C. decens*, *C. laticinctus*, *C. pipiens*, *C. tritaeniorhynchus* and *C. univittatus*, while in the latter village, they were in association with larvae of *C. univittatus*.

DISTRIBUTION: West Africa (INGRAM and MACFIE, 1917); Gambia, Nigeria and Transvaal (EDWARDS, 1911).

***Culex (Culex) theileri* Theobald**

Reported by PARR (1943) from Syria, but no information concerning the breeding places were given.

Larvae were collected by the author in swamps from the following villages: (1) Zarra (Kousseir casa, Homs) in May, in association with larvae of *C. laticinctus*, *C. mimeticus*, *C. pipiens* and *T. annulata*; (2) Mailobiye (Hassatche casa, Jesireh), in October, associated with those of *C. laticinctus* and *C. mimeticus*; (3) Tell-Hamdoun (Amouda casa, Jesireh), in October, in association with larvae of *C. laticinctus*, *C. mimeticus*, *C. mattinglyi*, *C. tritaeniorhynchus*, *C. univittatus* and *U. unguiculata*; and (4) Ras-el-Ain (Jesireh) in October, in association with those of *C. pipiens*, *C. tritaeniorhynchus*, *C. univittatus*, and *U. unguiculata*.

From temporary pools, larvae were obtained, in October, from the following villages: (1) Tell-Aarade (Ras-el-Ain casa, Jesireh), in association with those of *C. pusillus* and *C. mimeticus*; (2) Arbouch (Tell-Tamer casa, Jesireh), in association with those of *C. laticinctus* and *C. immeticus*; (3) Souar (Der-el-Zor casa, Euphrates), associated with those of *C. decens*, *C. laticinctus*, *C. mimeticus*, *C. tritaeniorhynchus*, and *C. univittatus*; and (4) Quiri Ziara (Deirik casa, Jesireh), associated with larvae of *C. mimeticus* and *C. univittatus*.

From springs, larvae were taken in the following villages: (1) Nebal-el-Fawage (Jisr-el-Chaghour casa, Aleppo), in September; (2) Babassi (Kamichli casa, Jesireh), in October, associated with larvae of *C. decens*, *C. mimeticus*, *C. tritaeniorhynchus*, *C. univittatus* and *U. unguiculata*; and (3) Khanik (Amouda casa, Jesireh), in October, associated with larvae of *C. mimeticus*, *C. mattinglyi*, *C. laticinctus*, *C. tritaeniorhynchus*, *C. univittatus* and *U. unguiculata*.

From irrigation canals, larvae were collected in two villages, Moudane (Kousseir casa, Homs) and Tell-Massas (Tell-Tamer, Jesireh). In the former village, the larvae were taken in May in association with those of *T. annulata*, while in the latter village, they were taken, in October, in association with larvae of *C. laticinctus* and *C. pipiens*.

DISTRIBUTION: Egypt (GOUGH, 1914); Syria and Lebanon (PARR, 1943); Iraq (KHATTAT, 1955); Yemen (KNIGHT, 1953B); Arabia (MATTINGLY and KNIGHT, 1956); Transvaal (EDWARDS, 1911).

***Culex (Culex) tritaeniorhynchus* Giles**

Previously reported from Syria by PARR (1943) where larvae were found in rain-water cisterns at Qoubbe during August.

This species appear to be one of the most common in the northern region of the United Arab Republic. Larvae were taken from a variety of breeding places including, swamps, a spring, a temporary pool and hoof prints.

From swamps, larvae were collected in the following villages: (1) Arida (Tell-Kalakh casa, Lattakia), in June, in association with those of *C. mattinglyi*, *C. molestus* and *C. univittatus*; (2) Ziara (Jisr-el-Chaghour casa, Aleppo), in September, in association with those of *C. laticinctus*, *C. univittatus* and *Aedes caspius*; (3) El-Rassif (Jisr el-Chaghour casa, Aleppo), in September, in association with those of *C. decens*, *C. laticinctus*, *C. pipiens*, *C. thalassius*, *C. univittatus*; (4) Souediye (Deirik casa, Jesireh), in October, associated with larvae of *C. laticinctus*, *C. mattinglyi*, *C. mimeticus*, *C. pusillus* and *C. univittatus*; (5) Khanik (Amouda casa, Jesireh) in October, in association with those of *C. laticinctus*, *C. mattinglyi*, *C. mimeticus*, *C. theileri*, *C. univittatus* and *U. unguiculata*; and (6) Ras-el-Ain (Jesireh), in October, associated with those of *C. pipiens*, *C. theileri*, *C. univittatus* and *U. unguiculata*.

Larvae of *C. tritaeniorhynchus* were also taken from a spring with algal floatage, in October, in the village Babassi (Kamichli casa, Jesireh) in association with those of *C. decens*, *C. mimeticus*, *C. theileri*, *C. univittatus* and *U. unguiculata*.

From a temporary pool on the side of an irrigation canal supplied from a sakia on the river Khabour in the village Souar (Deir-el-Zor casa, Euphrates), larvae were obtained in October, in association with those of *C. decens*, *C. laticinctus*, *C. mimeticus*, *C. theileri* and *C. univittatus*. They were also taken, in October, from hoof prints supplied with water from a spring in the village Ain Diwar (Deirik casa, Jesireh) in association with larvae of *C. hortensis*, *C. laticinctus*, *C. univittatus* and *U. unguiculata*.

DISTRIBUTION: Egypt (KIRKPATRICK, 1925); Syria and Lebanon (PARR, 1943); Palestine (BARRAUD, 1921); Iraq (BARRAUD, 1920); Arabia (MATTINGLY and KNIGHT, 1956) and West Africa (INGRAM and MACFIE, 1917).

***Culex (Culex) univittatus* Theobald**

According to PARR (1943) this species is common in all parts of Syria during the summer and autumn months. Breeding occurred in swamps, pools slow-running streams containing dense vegetation.

From the Ghab swamp, larvae were taken during September, in the following villages belonging to Jisr-el-Chaghour casa, Aleppo: (1) Ziara, in association with those of *C. laticinctus*, *C. tritaeniorhynchus* and *A. caspius*; (2) El-Rassif, in association with those of *C. decens*, *C. laticinctus*, *C. pipiens*, *C. thalassius*, *C. tritaeniorhynchus*; (3) Qleidine, larvae here were taken alone; (4) Kherbet-el-Naous, in association with those of *C. laticinctus* and *C. thalassius*; and (5) Houaiz. They were also obtained from a swamp, in June, in the village Arida (Tell-Kalakh casa, Lattakia), in association with larvae of *C. mattinglyi*, *C. molestus* and *C. tritaenior-*

hynchus. Larvae were also collected during October, from swamps supplied from springs in two villages in Jesireh Governorate, namely, Souediye (Deirik casa) and Khanik (Amouda casa). In the former village the larvae were in association with those of *C. laticinctus*, *C. pusillus*, *C. mattinglyi*, *C. mimeticus*, and *C. tritaeniorhynchus*; while in the latter village, they were associated with those of *C. laticinctus*, *C. mattinglyi*, *C. mimeticus*, *C. theileri*, *C. tritaeniorhynchus* and *U. unguiculata*.

From temporary pools larvae were collected during October, in two villages: (1) Souar (Deir-el-Zor casa, Euphrates), in association with those of *C. decens*, *C. laticinctus*, *C. mimeticus*, *C. theileri* and *C. tritaeniorhynchus*; (2) Quiri Ziara (Deirik casa, Jesireh), in association with larvae of *C. mimeticus* and *C. theileri*.

Larvae were taken once, in October, from a spring in the village Babassi (Kamichli casa, Jesireh) in association with those of *C. decens*, *C. mimeticus*, *C. theileri*, *C. tritaeniorhynchus* and *U. unguiculata*.

From hoof prints supplied with water from a spring, with algal floatage, in the village Ain-Diwar (Dirik casa, Jesireh), larvae of this species were obtained in October, in association with those of *C. hortensis*, *C. laticinctus*, *C. tritaeniorhynchus* and *U. unguiculata*.

DISTRIBUTION: Egypt (BARRAUD, 1921); Sinai (ABDEL-MALEK, 1956); Syria (PARR, 1943); Lebanon and Palestine (BARRAUD, 1921); Yemen (KNIGHT, 1953B); Arabia (MATTINGLY and KNIGHT, 1956); Sudan, Nigeria, Gold Coast and East Africa (EDWARDS, 1912).

The following is a key for the identification of the larvae of the *Culicine* species of mosquitoes encountered in the northern region of the United Arab Republic. This key has been adapted from EDWARDS (1921), HOPKINS (1936), KIRKPATRICK (1925), KNIGHT (1953B) and MARSHALL (1938).

KEY TO LARVAE

1. Siphon absent **Anophelinae**
- Siphon present **Culicinae** 2
2. Siphon with one pair of subventral tufts 3
- Siphon with several subventral tufts **Culex** 9
3. Siphonal tuft at the base **Theobaldia** 5
- Siphonal tuft near the middle 4
4. A large chitinous plate on each side of the eighth abdominal segment, at the apex of which is a comb of 6 to 8 spines in a single row .. **Uranotaenia unguiculata**
- No chitinous plate on the eighth abdominal segment, only a patch of scales or a comb of a single row..... **Aedes** 7
5. Siphon with 8 to 12 widely-spaced pecten teeth **T. longiareolata**
- Siphon with pecten teeth more compact and with their tips drawn out into long hairs 6

6. The post-clypeal hairs and the inner-frontal hairs about the same distance apart **T. annulata**
The post-clypeal hairs are closer together than the inner-frontal hairs....
..... **T. subochrea**
7. Antennae with a single small hair on the shaft. Comb on eighth abdominal segment a single curved row of 7 spines..... **A. aegypti**
Antennae with a small tuft of several hairs. Comb on eighth abdominal segment a patch of scales..... 8
8. Siphon about $1\frac{1}{2}$ times as long as broad. Shaft of antenna almost without spicules **A. mariae**
Siphon about 2 times as long as broad. Shaft of antenna with conspicuous spicules **A. caspius**
9. Comb of eighth abdominal segment composed wholly of spines **C. theileri**
Comb of eighth abdominal segment composed entirely of scales 10
10. Siphon with first 2 or 3 hair tufts between the pecten teeth..... 11
Siphon with none of the hair tufts between the pecten teeth 13
11. Siphon rather less than 3 times as long as broad..... **C. pusillus**
Siphon at least 4 times as long as broad, generally much more..... 12
12. Head and siphon dark brown. Siphonal tufts 8 to 10, in a zigzag ventral row. Pecten with 11 to 16 spines..... **C. laticinctus**
Head and siphon pale. Siphon with 11 to 16 subventral tufts. Pecten with 14 to 19 teeth. Thoracic integument distinctly spiculated **C. mattinglyi**
13. Siphonal index 6 or more..... 14
Siphonal index less than 6 18
14. Siphonal tufts rather numerous, some much longer than the diameter of the siphon 15
Siphonal tufts fewer, none longer than the diameter of the siphon..... 16
15. Antennae pale except on the portion beyond the sub-apical bristles; sub-apical bristles only a little more than half way along the portion of the shaft beyond the antennal tuft **C. mimeticus**
Antennae entirely or at least more than half dark; sub-apical bristles quite near the tip **C. hortensis**
16. Siphonal index 9 to 10. Ventral pair of gills much shorter than dorsal pair **C. decens**
Siphonal index 7 to 8. Gills subequal..... 17
17. Index about 7. Pecten with 10 to 14 spines; pecten extends to little beyond $\frac{1}{4}$ of siphon **C. univittatus**
Index about 8. Pecten with 9 to 13 spines; pecten extends to nearly $\frac{1}{3}$ of siphon **C. tritaeniorhynchus**
18. Gills very short, rounded, dorsal pair little more than $\frac{1}{3}$ length of saddle, ventral slightly smaller **C. thalassius**
Gills more or less $\frac{3}{4}$ length of saddle..... 19

19. Siphonal index about $3\frac{1}{2}$. Pecten with about 9 teeth. **C. fatigans**
 Siphonal index more than 4. Pecten usually 12 to 14 teeth. 20
20. Siphonal index usually more than 5 **C. pipiens**
 Siphonal index never more than 4.8, usually less. **C. molestus**

SUMMARY

A collection of Culicine mosquito larvae made in the northern region of the United Arab Republic, is the basis of this paper. Twenty species were encountered, eight of which are new to the area. These newly recorded species are: *Aedes caspius* Pallas, *Aedes mariae* Sergeant, *Culex decens* Theobald, *Culex fatigans* Wied., *Culex mattinglyi* Knight, *Culex pipiens* Linn., *Culex pusillus* (Macq.) Storey, and *Culex thalassius* Theobald. Records of distribution and biological notes are given for all the twenty species encountered, together with a simple key for their identification.

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ON OPEN-AIR AND UNDERGROUND GRAIN STORAGE IN THE SUDAN

(with 3 Text-Figures and 8 Tables)

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Dura (Millet, *Sorghum vulgare*) is stored in the Sudan in different ways, the open-air and underground storage are mainly the most important. In Khartoum North, the main centre of grain storage in the Province, sacks of different varieties of dura are arranged in pyramids and placed on a wide area of concrete floor. Each pyramid stands on a wooden floor and sacks are arranged in a rectangular block of about 13×13 wide by 2 metres high surmounted by a truncated part of about 6 metres high. Each pyramid contains several thousands of sacks each weighing 80-90 kilos. Most pyramids are placed in a straight line running from north to south and are one metre apart. At the time when these observations were carried out there was one pyramid standing away from the line on a specially constructed base exposed to the sun from all directions. The first pyramid at the southern end on the line was short and incomplete and therefore samples were taken from the next two pyramids together with that which stood away from the main line.

In Gedaref area, Kassala Province, dura is stored in pits holding varying amounts of grain. In Wad El Huri, the centre of the Mechanised Crop Production Scheme, six experimental pits each of 100 tons capacity were filled in 1953, three with Fitereta and three with Red Mugud grain, two of the common varieties of dura. The pit is about 70 m. long, 10 m. wide and 4 m. deep, and they were all dug in high level ground where the water table is low. The walls were quite porous as they were left unsealed. The experimental pits were filled with loose grain and earth was heaped on them to a height of 3-4 m.; others were filled with sacked grain and covered with soil in the same way.

This investigation was carried out in order to look into the efficiency of the two ways of grain storage and, as the experimental pits at Wad El Huri were emptied after a period of six years, it has been felt desirable to examine the grains after such

a long period of storage. There are certain data which are necessary to judge the efficiency of pit-storage of grain and which have to be recorded throughout the experiment. These are: (1) the moisture content of the grain, (2) the presence or absence of living insects, (3) the viability of the grain, (4) the build up of carbon dioxide concentration, (5) the fall in oxygen concentration and (6) the temperature of the grain. (1), (2) and (3) were carried out during 1957-59 but (4), (5) and (6) were not obtainable owing to the lack of necessary equipments.

In Khartoum North, samples were taken from the peripheral 10 cm. of the sacked grain by an ordinary conical spear. Equal surface areas of the exposed surfaces of the sacks were swept and living and dead insects were counted. This was carried out along the four sides of the pyramids facing the cardinal directions at different heights. In Wad El Huri earth was removed at different points and superficial samples were taken from the pits. Samples were transferred to the Faculty in Khartoum North, Shambat, in air-tight jam-jars, sorted out into sound and damaged grains, insects collected and counted and moisture content was determined by heating grain for a period of two days at 105°C.

Through the kindness of the Store Department in Khartoum North and Chief Inspector of Agriculture, Wad El Huri, we had access to the grain and allowed to obtain samples for examination.

Khartoum North open-air grain storage

The arrangement of pyramids in a line running from north to south exerted certain temperature variations inside the sacks along the four sides of the pyramids especially at the rectangular blocks. In winter, for instance, the sides of blocks and truncated pyramids facing north will not be exposed to the sun, whereas the sides of the blocks facing south will be always shaded by the adjacent pyramids and the upper parts will be exposed to the sun. In summer, the reverse takes place, the sides

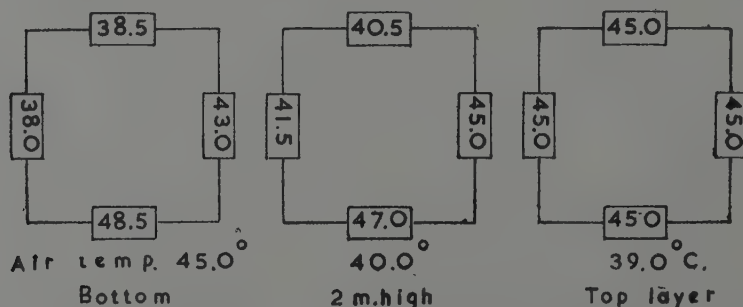


FIG. 1: A diagram showing the variation in air and grain temperature. The grain temperature was taken at 5 cm. deep in the superficial sacks of pyramid (1) on 20th November 1957 between 11.30 a.m. and 1.00 p.m.

facing south will not be exposed to the sun and the sides of the blocks facing north will be always shaded by the adjacent pyramids and the upper parts will be exposed to direct sun rays. The variation in temperature brought about by such arrangement will cause *Trogoderma granarium* and other insects to undergo a special pattern of distribution. Figure 1 shows the temperature of grain inside the sacks at about 5 cm. deep together with air temperature at three different levels: the bottom layer, 2 m. high (the end of the rectangular block) and the top layer of sacks on 20th November 1957 between 11.30 a.m. and 1.00 p.m. The temperature of the grain is consistently higher than air temperature at this time of the day. Air temperature at the bottom of the pyramid is very high because of reflection from the concrete floor. Temperature inside sacks facing south is highest among all sacks of the same level whereas the temperature in sacks facing north is lowest; variations have disappeared near the top layer of sacks.

Dura, mainly Fitereta, Mugud and Wadakar is brought from Gedaref area, the main centre of dura production, and stored in this way for a varying length of time. During the rainy season, July-September, sacks are covered by heavy tarpaulin. The area is harbouring a high population of *Trogoderma* the larvae of which are able to withstand a long period of hunger, dry conditions and high temperature prevailing in the district. They are found in great numbers in cracks of the concrete base and adjacent buildings and huge masses of the moulting skin and crawling adults are generally found on sacks.

Pyramid (No. 1) contained 5687 sacks of dura (Wadakar) which have been in store for one year and eight months. Sweeps and samples were taken on 20th November 1957 between 11 a.m. and 1 p.m. Results are shown in Tables I and II. The bottom layer is generally harbouring more insects than those lying above. Counts indicate the almost absence of insects in the top layer of sacks and that the intermediate layer (2 m. from the ground) harboured a population which was generally less than that of the bottom one. The anomaly shown in the middle sample taken from the south direction which was unexpectedly higher than the bottom one may be due to including, accidentally, insects lying between sacks in that sample.

The insects crawling on the surfaces of the sacks were mostly adults, the number of larvae was rather negligible. In November, when samples of grain and sweeps were taken the sides of the pyramids facing north were not exposed to direct sun light and this resulted in conditions well suited for the accumulation of insects. Adult *Trogoderma* prefers shade and moderate temperature and this was apparent by the highest number of adults found on the bottom sacks facing north and the lowest number on those facing south; temperatures in the superficial layer of grain were 38.5 and 48.5°C., respectively. 1012 insects (24.8% living) were taken in a sweep from a sack facing north, whereas 194 insects (11.3% living) were taken in a sweep from a sack facing south. Again, the temperature of grain in a sack facing east was much higher than in a sack facing west; this corresponded with the number of insects taken in sweeps at both sides: 489 adults (5.5% living) and 683 (4.5% living)

TABLE I
Pyramid (1): Numbers of *Trogoderma* found in sweeps.

Heights	North						South						East						West						Total of Totals							
	Larvae			Adults			Total	Larvae			Adults			Total	Larvae			Adults			Total	Larvae				Adults			Total			
	L	D	L	L	D	L		D	L	D	L	D	L		D	L	D	L	D	L		D	L	D		L	D	L		D	L	D
Bottom sacks	1	0	250	761	1012		16	4	6	168	194	0	0	27	462	489	0	0	31	652	683								2378			
Sacks 2m. high	0	0	18	113	137a		0	0	9	900	909	0	0	11	87	98	0	0	1	35	37b								1181			
Top sacks	0	0	0	3	3		0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0							4			
Totals						1152					1103					588					720								3563			

L = living; D = dead; a 6 dead *Tribolium* adults were also found; b= 1 living *Tribolium* adult was also found.

L=living; D=dead; a=6 dead *Tribolium* adults were also found; b=1 living *Tribolium* adult was also found.

TABLE II

Pyramid (1): Numbers of *Trogoderma* and other insects found in samples of approximately 50 gms. of grain, dura Wadakar.

Heights	North						South						East						West						Total of Totals																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
	Larvae			Adults	No. other insects	Total	Larvae			Adults	No. other insects	Total	Larvae			Adults	No. other insects	Total	Larvae			Adults	No. other insects	Total																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
	L	D	L				D	L	D				L	D	L				D	L	D					L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L</

L=living; D=dead; a=12 dead *Rhizopertha* adults, 4 dead *Tribolium* adults, 6 dead *Leptothrips* adults; b=1 living *Tribolium* adult, 3 dead *Oryzaephilus* adults, 3 dead *Lothricus* adults; c=1 dead *Rhizopertha* adult, 2 dead *Leptothrips* adults; d=2 dead *Tribolium* adults; e=2 dead *Tribolium* adults; f=2 dead *Tribolium* adults; g=5 dead *Oryzaephilus* adults, 2 dead *Rhizopertha* adults, 2 dead *Leptothrips* adults, 3 dead *Tribolium* adults, 5 dead *Leptothrips* adults, and 1 dead *Calandra* adult.

in east and west respectively. Of the adults found in sweeps the majority was dead: 10% living and 90% dead.

When the larvae are mature and ready to pupate they come to the surface of the grain and the adults upon emergence from the last larval skin spend most of their lives crawling on the sacks. *Trogoderma* infestation is always characterized by the accumulation of moulting skin between sacks and the occurrence of such masses between sacks of the bottom layer indicated its highest abundance in this part of the pyramid and proved the larvae negative phototropic reaction (RAHMAN and SOHI, 1939).

Table II shows the number of insects found in samples drawn from the superficial sacks of the same pyramid at different heights and directions. The abundance of insects in sacks of the bottom layer and in those facing north is in agreement with the previous findings. But out of the total number of insects 62.7% were larvae and of these larvae 59.7% living. Beside *Trogoderma* many other insects were also encountered, and most of them were dead. *Laemophloeus* and *Calandra* must have been brought in with the grain from Gedaref as they do not normally occur in the Northern Province, nor can they be reared in the laboratory under natural conditions. The moisture content of grains (Dura Wadakar) obtained from these superficial sacks was 5.12%.

The grains in the next pyramid (No. 2) were in store for only seven months and the infestation was much lighter. There were no crawling insects on sacks and the moulting skin indicating *Trogoderma* infestation was also absent. Table III shows the number of insects found in samples drawn from the superficial layer of grain. Such small initial infestation which normally occurs in this district does not show any clear distribution save that the insects tend to increase in number from up downwards, and that the sample taken from the bottom layer from a sack facing north contained a slightly higher number of insects. The numbers of insects in sacks facing north and west were apparently higher than in other sacks facing south and east. *Tribolium* larvae and adults form the majority (77.4%) of insects found in these samples. The percentage damaged grain shown in the Table, though cannot be totally attributed to the present infestation shows that the bottom layer is likely to undergo the heaviest loss. The moisture content of grains (Dura Fitereta) was 6.66%.

Samples were also taken from a third pyramid the grains of which were in store for 19 months. In addition to samples taken from the peripheral sacks others from the central core of the pyramid were also taken (Fig. 2). This pyramid stood away from the main line of the others and its sides were not properly facing cardinal directions. The infestation in the peripheral sacks was very slight, in 12 samples (3 samples at different heights from 4 sides) of approximately 50 gm. each 16 insects were found: 12 *Tribolium*, 3 *Rhizopertha* and 1 *Trogoderma*. The number of crawling insects was also negligible.

TABLE III

Pyramid (2): Numbers of insects found in samples of approximately 50 gms. of grain, dura *Fitereta*.

Heights	North	South	East	West	Total of Totals
Bottom sacks	17 living <i>Tribolium</i> adults; 1 dead <i>Tribolium</i> larvae. <u>18 Total</u>	3 living <i>Trogoderma</i> larvae; 1 dead <i>Rhizopertha</i> adult. <u>4 Total</u>	1 dead <i>Trogoderma</i> adults; 1 dead <i>Tribolium</i> adult; 1 dead <i>Rhizopertha</i> adult. <u>3 Total</u>	7 living <i>Tribolium</i> adults; 4 dead <i>Tribolium</i> adults; 1 living <i>Rhizopertha</i> adult; 1 dead <i>Rhizopertha</i> adult. <u>13 Total</u>	38
Percentage damaged grain	5.44	5.37	3.51	3.34	
Sacks 2m. high	1 living <i>Tribolium</i> adult 2 dead <i>Tribolium</i> adults 1 dead <i>Rhizopertha</i> adult <u>4 Total</u>	1 dead <i>Rhizopertha</i> adult. 2 dead <i>Tribolium</i> adults <u>3 Total</u>	1 dead <i>Rhizopertha</i> adult 1 dead <i>Tribolium</i> adult. <u>2 Total</u>	2 living <i>Tribolium</i> larvae 8 dead <i>Tribolium</i> adults. 1 dead <i>Rhizopertha</i> adult. <u>11 Total</u>	20
Percentage damaged grain	3.18	2.32	0.68	7.85	
Top sacks	1 dead <i>Calandra</i> adult			2 dead <i>Tribolium</i> adults; 1 dead <i>Trogoderma</i> larva. <u>3 Total</u>	4
Percentage damaged grain	0.56	1.70	1.32	1.52	
Total number of insects	23	7	5	27	62

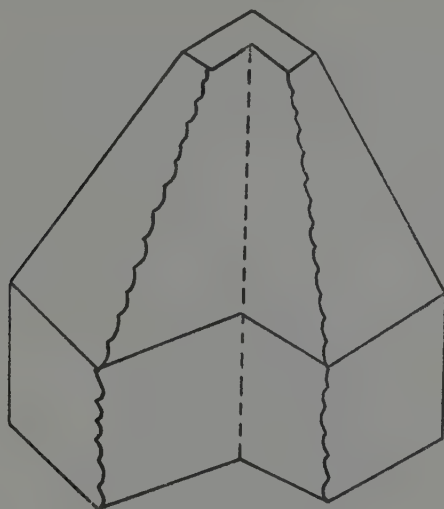


FIG. 2: Pyramid (3) in which sacks in one of the corners were removed and samples taken along the central core indicated by a broken line.

The information obtained from examining samples taken from sacks in the central core of the pyramid is summarized in Table IV. Larger samples were taken in one-pound jam jars. Judging by the number of insects it is evident that the inward sacks were harbouring more insects than peripheral ones. But the gradual

TABLE IV

Pyramid (3): Result of examining samples of grain taken from the central core at different heights.

Layer of sack	Number <i>Trogoderma</i> in sample				Total	Percentage moisture in		Percentage damaged grain
	Larvae		Adults			sound grain	damaged grain	
	<i>L</i>	<i>D</i>	<i>L</i>	<i>D</i>				
1st (bottom)	46	2	0	1	51a	6.80	7.07	7.78
3rd	45	2	0	0	47	6.56	7.85	1.92
5th	10	3	0	0	13	6.58	7.49	2.36
8th	15	0	0	0	15	6.86	7.02	1.53
12th	36	1	2	0	39	6.74	6.98	1.65
17th	19	1	31	16	67	6.53	7.00	2.77
19th (top)	5	0	0	0	5	6.59	7.14	1.05

L=living; D=dead; a=2 *Tribolium* adults were also found.

change in the number of insects with regard to height which was apparent in the peripheral samples in other pyramids has disappeared. However, the percentage damaged grain seems to attain the highest value at the bottom. The percentage of moisture content of damaged grain is consistently higher than that of sound ones.

Wad El Huri underground grain storage

Peripheral grain samples were obtained from the experimental pits at Wad El Huri on three different occasions: December 1957, March 1958 and January 1959. On the first occasion one sample was taken from each pit, but on the second five samples were obtained; pit No. 4 was found empty. One sample was taken from a point at the centre of the surface layer and the other four at points close to the walls of the pit at the four cardinal directions. This was carried out in order to ascertain whether moisture content of grain would increase near the walls of the pit. On the third occasion samples were taken in the same way from two pits only (Nos. 5 and 6); the others were found empty. Samples were obtained in two-pound jam jars.

The result of investigating grain samples taken in December 1957 is shown in Table V, from which it can be shown that Fitereta pits were harbouring more insects than those of Mugud. But insect pests being *Tribolium*, *Rhizopertha* and *Laemophloeus* (arranged in order of abundance) could not be expected to cause any serious damage. The percentage damaged grain which is higher in Fitereta than in Mugud could be attributed to insect attack prior to storing. Grasshoppers seem to show a certain preference to some varieties of dura.

TABLE V

*Result of examining peripheral grain samples
taken from experimental pits at Wad El Huri, December 1957.*

Number of pit	Percentage water content	Mean percentage water content	Percentage damaged grain by weight	Number insects per 100 gms. of grain
Fitereta {	1	10.05	11.84	12.48
	2	11.01	11.80	13.41
	3	9.80	13.44	3.03
Red Mugud {	4	12.43	1.69	8.17
	5	9.67	1.74	—
	6	12.20	1.02	1.33

Considering the past history of these pits, it was shown by JOYCE (1954) that water content in November 1954 was 8.43 and 12.83% in Fitereta and Mugud grain respectively. In December 1957 an increase of 1.86% moisture occurred in Fitereta and a decrease of 1.40% in Mugud.

The result of examining grain samples taken in March 1958 is shown in Table VI, and summarized in Table VII. The insect fauna comprises mostly insects of secondary importance and the percentage damaged grain which is consistently higher in Fitereta than in Mugud — and this is in agreement with the previous findings — could be attributed to grasshopper damage prior to storing. The total numbers of insects found in the samples of the five pits are represented in Figure 3; *Trogoderma*, being one insect out of a total of 470, is not represented.

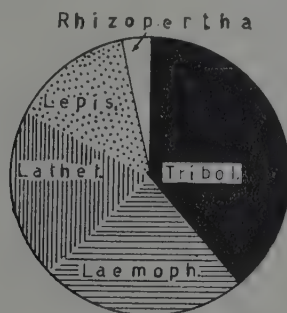


FIG. 3: A diagrammatic representation of the total number of insects found in samples taken from the experimental pits at Wad El Huri, March, 1958.

With regard to moisture content of grain it can be noticed that in Fitereta pits (Nos. 1, 2 and 3) the central samples contained the lowest values (Table VI). In pits Nos. 2 and 3 the highest value occurred in samples close to the side facing west and in pit No. 1, though the west sample contained an amount of moisture which was considerably higher than that of the centre, the north sample contained the highest moisture content. The grain close to the walls of the pits were absorbing water from the moist air inbetween soil particles, and it seemed that air moisture was not uniformly distributed along the four sides of the pits.

In pits Nos. 5 and 6 which were holding Mugud grain the moisture content was on the whole higher than that of Fitereta, the mean moisture contents were 12.49 and 11.91% respectively (Table VII). In pit No. 6 grain of the central sample contained the lowest moisture content but in No. 5 all samples contained approximately the same amount of moisture except that brought from the west direction which contained an appreciably higher amount of moisture. The number of insects per 100 gm. of grain and the percentage damaged grain were appreciably lower than that of Fitereta. This is in agreement with the previous findings. The reason for a higher population of insects in Fitereta pits is at the moment difficult to explain. It may be that pits harboured initial infestations which were different in intensity before the two varieties of dura were stored. There is also the likelihood of a different effect of the two varieties of dura upon the fertility of insects. It is worth noting that

TABLE VI

*Result of examining grain samples taken from pits at Wad El Huri,
Kassala Province, Sudan, in March 1950.*

Direction	Percent- age of moisture	Mean of moisture	Number of insects in sample	Number of insects per 100 gms. of grain	Mean	Percent- age damaged grain	Mean
Pit No. 1 (Fitereta)	Centre	9.90	5 Rhizopertha (4-1) 13 Tribolium (6-7) 5 Lepismatidae (5-0)	4.23		4.08	
	North	13.14	1 Trogoderma (1-0) 7 Tribolium (5-2) 3 Laemophloeus (2-1) 2 Lepismatidae (2-0)	3.13		12.82	
	South	12.38	7 Tribolium (7-0) 2 Latheticus (2-0) 15 Laemophloeus (15-0) 10 Lepismatidae (10-0)	9.42	6.40	38.19	23.16
	East	11.84	23 Tribolium (23-0) 7 Latheticus (7-0) 4 Laemophloeus (4-0) 3 Lepesmatidae (3-0)	9.54		45.97	
	West	12.80	1 Tribolium (1-0) 12 Laemophloeus (11-1) 12 Lepismatidae (7-5)	5.67		14.74	
	Centre	10.50	4 Tribolium (4-0) 3 Latheticus (3-0) 1 Laemophloeus (1-0) 6 Lepismatidae (6-0)	2.79		4.62	
	North	12.70	19 Tribolium (18-1) 15 Laemophloeus (15-0) 3 Lepismatidae (3-0) 1 Rhizopertha (0-1)	7.49		20.95	
	South	12.48	43 Tribolium (34-9) 22 Latheticus (18-4) 7 Laemophloeus (6-1) 1 Lepismatidae (0-1)	15.10	9.14	18.52	18.16
	East	11.34	11 Rhizopertha (8-3) 24 Tribolium (22-2) 59 Latheticus (57-2) 12 Laemophloeus (12-0)	18.43		32.00	
	West	14.13	1 Tribolium (1-0) 7 Laemophleus (7-0) 1 Lepismatidae (1-0)	1.90		14.67	

The numbers between brackets indicate living and dead insects, respectively.

TABLE VI (Continued)

Result of examining grain samples taken from pits at Wad El Huri,
Kassala Province, Sudan, in March 1958.

Direction	Percent- age of moisture	Mean of moisture	Number of insects in sample	Number of insects 100 gms. per of grain	Mean	Percent- age damaged grain	Mean				
Pit No. 3 (Fiterata)	Centre	9.52	{ 2 Lepismatidae (02-0) 27 Tribolium (27-0) 2 Laemophloeus (02-0) 1 Lepismatidae (01-0) 5 Tribolium (04-1) 5 Lepismatidae (05-0) 3 Lepismatidae (03-0) 2 Tribolium (01-1) 11 Laemophloeus (11-0) 2 Lepismatidae (02-0)	0.39	{ 3.81	3.80	{ 10.89				
	North	10.60		6.34		18.79					
	South	12.24		2.26		5.57					
		East		10.61		6.33		5.45			
	West	14.42		3.75		20.84					
	Pit No. 5 (Mugud)	Centre		12.92		{ 8 Laemophloeus (08-0) 3 Lepismatidae (03-0) None None 3 Laemophloeus (03-0) None		2.26	{ 0.59	5.10	{ 4.16
		North		12.96				—		5.10	
South		12.85	—	2.15							
East		13.10	0.68	5.27							
West		13.84	—	3.16							
Pit No. 6 (Mugud)	Centre	11.37	{ 1 Tribolium (01-0) 2 Laemophloeus (02-0) 3 Lepismatidae (03-0) 3 Laemophloeus (03-0) 2 Lepismatidae (02-0) 1 Tribolium (00-1) 1 Latheticus (01-0) 1 Laemophloeus (01-0) None 3 Tribolium (03-0) 6 Laemophloeus (06-0) 1 Lepismatidae (00-1)	1.35	{ 1.07	2.50	{ 3.39				
	North	11.64		1.06		1.22					
		South		11.55		0.70		0.70			
	East			13.26		—		7.22			
				West		11.39		2.24	2.74		

The numbers between brackets indicate living and dead insects, respectively.

all seeds were found to have lost their viability; 100 grains from each sample were examined for germination and they were all found dead.

In January 1959 when Wad El Huri was visited Fitereta pits were found empty and pits Nos. 5 and 6 which contained Mugud grain were in the process of empty-

TABLE VII. — *Result of examining grain samples taken from pits at Wad El Huri, March 1958, summarized from Table VI.*

Number of pit	Mean percentage moisture content	Mean of means	Percentage damaged grain by weight	Number insects per 100 gms. of grain
Fitereta	1 12.01	11.91	23.16	6.40
	2 12.23		18.16	9.14
	3 11.48		10.89	3.81
Red Mugud	5 13.13	12.49	4.16	0.59
	6 11.84		3.39	1.07

TABLE VIII. — *Result of examining grain samples taken from pits at Wad El Huri, in January 1959.*

Direction	Percentage of moisture	Mean of moisture	Number of insects in sample	Number of insects per 100 gms. of grain	Mean	Percentage damaged grain	Mean
Pit No. 5 (Mugud)	Centre { s. 7.76	8.56	{ None	{ —	2.61	{ 9.02	5.91
	D. 8.27		{ None	{ —		{ 6.13	
	North { s. 6.43		{ None	{ —		{ 3.12	
	D. 5.26		{ None	{ —		{ 7.47	
	South { s. 11.94		{ 20 Laemophloeus (20-0)	{ 9.39		{ 3.82	
	D. 10.86		{ 1 Tribolium (1-0)	{ 3.65		{ 13.12	
	East { s. 10.25		{ 9 Laemophloeus (9-0)	{ —		{ 1.53	
	D. 10.37					{ 12.69	
	West { s. 7.15					{ 14.18	
	D. 7.27					{ 1.32	
Pit No. 6 (Mugud)	Centre { s. 8.18	8.80	{ None	{ —	3.93	{ 13.12	8.57
	D. 7.96		{ 7 Tribolium (2-5)	{ 7.14		{ 1.53	
	North { s. 8.40		{ 3 Laemophloeus (1-2)	{ 7.01		{ 12.69	
	D. 7.62		{ 2 Rhizopertha (0-2)	{ 5.52		{ 14.18	
	South { s. 9.65		{ 6 Tribolium (1-5)	{ —		{ 1.32	
	D. 9.19		{ 7 Laemophloeus (7-0)	{ —		{ 13.12	
	East { s. 11.38		{ 2 Tribolium (0-2)	{ —		{ 1.53	
	D. 9.77		{ 1 Latheticus (1-0)	{ —		{ 12.69	
	West { s. 8.13		{ 10 Laemophloeus (9-1)	{ —		{ 14.18	
	D. 7.74		{ None	{ —		{ 1.32	

S=sound grain; D=damaged grain.

The numbers between brackets indicate living and dead insects, respectively.

ing. Five samples were taken in the ordinary way from the remaining amount of grain found at the bottom of the pits and so the sample obtained from the centre would not represent the superficial layer but another one 2-2.5 metres below. The result of examining these samples is shown in Table VIII.

After such a long period of storage, nearly 6 years, most of the grains was found to have changed their normal red and acquired a dark black colour. They had a distinct musty smell, rot fungi were apparent on the surface and seeds much shrivelled. The grains in the centre of the pits were either normal in appearance (pit No. 6) or a mixture of normal and discoloured ones (pit No. 5). It seems that there was a gradual change to the deteriorated condition from the walls inwards. As a result of growth of fungi grains seem to have lost much of their water contents. The mean moisture content was 8.68% in January 1959 and 12.49% in March 1958. It can also be seen from the Table that in most cases the damaged grains contained a lower amount of moisture than the "sound" ones. This appears to be in contrast with what has been shown in Table IV. But the growth of fungi resulted in decreasing the moisture content in what remained of the damaged grains. The insect fauna is similar to 1958 findings except that Lepismatidae was not encountered and the number of insects did not very much increase.

SUMMARY

In Khartoum Province grains of millet (*Sorghum vulgare*, *dura*) are subject to serious attack by *Trogoderma granarium* when stored in the open. In heaps of sacks arranged in pyramids the attack was found to be most serious in the bottom layers and lessens with the increase of height. This is most probably a direct reaction to sun light; *Trogoderma* is known to be negatively phototropic much in the larval stage than in the adult, the upper part of the pyramids is mostly exposed to direct radiation. The difference in the degree of infestation along the four sides of the pyramids was found to be due to differences in temperature and shade.

The underground grain storage is an ideal method provided that grain should not be in store for more than five years. Grains stored for such a period were found to lose their viability. Insects found in pits were all of minor importance but the majority was alive. This shows that even after this very long period of storage, i.e., about 6 years, the intergranular air had not reached a condition completely fatal to insects. Walls of pits were cracked and porous allowing carbon dioxide to leak out. The damage encountered was the result of grasshopper attack prior to storing. Grasshopper seem to show a certain preference to certain varieties of *dura*. Conditions in the pits were not uniform, in the centre of the superficial layer grains were found to contain a lower amount of moisture than along the periphery where they had the chance of absorbing water from the presumably moist air inbetween soil particles.

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THE SUSCEPTIBILITY OF DIFFERENT VARIETIES OF COTTON PLANTS TO INFESTATION WITH INSECT AND MITE PESTS

(with 8 Tables)

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I. INTRODUCTION

An important part of any well-rounded insect control project should be the search for sources of insect resistance, and the use of varieties having such resistance in reducing the populations of insects and the damage done by them.

The search for sources of resistance must precede the study of inheritance of resistance. A valuable beginning has been made in the use of insect resistant plants to control insect populations and damage. A little progress has also been made in understanding the basis of resistance which is proving to be more complex than many have thought it to be. Almost invariably varieties resistant to one insect may be susceptible to another. Newer technique in chemical analyses should help in identifying the chemical bases of resistance and, in special cases, give practical help in tracing the genes concerned in insect resistance (PAINTER, 1958).

The variables in the complex bases of resistance of plants to insect infestation include (a) the morphology of the plant, (b) the stage of growth of the insect and of the plant, (c) the concentration of resistance factors or susceptible factors.

MAY (1952) and KNIGHT (1954) worked on resistance of leaf hoppers and other insects in cotton.

The Egyptian Agricultural Society was able to create, through selection, three varieties of cotton plants that possess wild characteristics viz. the pubescent variety, the semi pubescent variety and the curly-leaf variety (ABDEL BARI, 1950). The present work is an effort to compare the susceptibility of such wild varieties with that of two other cultivated varieties (Menoufi and Giza 30) against the infestation of insect and mite pests. The cotton wool of the three wild varieties are of short fibres while that of the two cultivated varieties are of long fibres.

The field experiment was in the Bahteem Experiment Station, 20 miles north of Cairo.

II. PROCEDURE

Each of the five tested varieties was cultivated at random in four replications, each of 3×7 metres and containing six rows of cotton plants. Cultivation took place on March 10, 1958; irrigation and manuring was practiced according to the usual manner followed in the area. Beside the four replications each variety was also cultivated in separate rows and in pots for reason of artificial infestation and for laboratory tests.

Since the appearance of the seedlings they were carefully inspected. Those of the pubescent variety grew slowly and many of them failed to show and had to be resown. This retardment of growth continued throughout the first two months after which the pubescent plants started to grow more vigorously than the other four varieties. The curly leaf cotton plants were dwarfs and shorter than the Menoufi.

One month after the date of planting adult thrips of *Thrips tabaci* Lind. started to appear on the leaves of the seedlings. This is the first generation of the pest on cotton plants. After winter hibernation the thrips (mostly of the adult form), move from the weeds to the seedlings (GHABN, 1948). Estimate of infestation was carried out by counting the adult and nymphal thrips on 20 seedlings selected from the four replications of each variety (ABUL-NASR and NAHAL, 1956). Counting was achieved every three days throughout the period of thrips infestation until the end of May.

Clean seedlings in the pots were covered with muslin bags and then a certain number of thrips were introduced into each pot. Also damage to the plants of each variety was estimated.

Aphid infestation was suspected during April and May but very few insects were found on the plants in the field. More aphids were found on the seedlings in the pots that were kept in the glass house.

From the beginning of June inspection for the egg masses of the cotton leaf-worm *Prodenia litura* F. was carried out daily. Most of the egg masses were hand picked for reason of counting, and a few were left to determine their destiny in connection with the egg hatching. Enforced infestation was tried on the plants standing in the field by fixing a number of egg masses on their leaves or by introduc-

ing *Prodenia* larvae, of different instars, into the covered plants. Also *Prodenia* larvae were bred in captivity and were offered leaves of the five tested varieties at one time.

Since the first week of August cotton bolls were collected and searched for the boll worms until the beginning of October. Twenty bolls from each variety were examined every three days and the number of the pink-boll worms *Pectinophora gossypiella* Saunders and the spiny boll worms *Earias insulana* Boisd. were recorded separately.

Infestation with aphids and spider mites became quite obvious since the beginning of August. A hundred leaves from the four replications of each variety were collected at random every three days until the beginning of October. Infestation with the spider mites was determined by the aid of a magnifying lens and degree of infestation was recorded under three categories, according to the symptom of damage and density of mites. If more than half the leaf surface had turned reddish brown and contained more than 50 individual mites, the infestation was considered heavy. If the reddish brown colour was spotty and the leaf contained between 20 to 50 mites, the infestation was moderate. In case the leaf was pale green and contained less than 20 mites the infestation was light.

The infestation with aphids was assorted also into three categories. If the lower surface of the leaf was covered with aphids and plenty of their cast skins, the infestation was considered heavy. If the insects gathered heavily only around the mid ribs, the infestation was moderate. But if the insects were few and scattered, the infestation was light.

At the end of August a marked number of bolls were shed or became small and dry due mostly to insect attack. Small greenish bugs appear on cotton plants; the boll shedder *Creontiades pallidus* Ramb. (Hemiptera-Heteroptera: Miridae) and the leaf-hoppers *Empoasca decipiens* Paoli. After the first and second pickings dry and shed bolls in all the replications were counted separately.

Cotton wool that was collected in the two pickings of each tested variety was weighed separately.

III. RESULTS

(1) The cotton thrips (*Thrips tabaci* Lind.)

Insect thrips infested the cotton seedlings while the anatomical characteristics of the tested varieties have not yet been distinguished. Thus, infestation with these insects did not reveal definite indication of preference among the five tested varieties. This indifferent condition continued until the third generation of thrips on cotton plants at the beginning of May. At that time nymphal thrips were found in a rather heavier population on the curly and pubescent leaves (Table I). Nymphal thrips might prefer such surfaces for reason of thigmotropic response. WATT (1934).

believes that moulting of immature stages may, in some way, be connected with this response. DETHIER (1953) has correctly emphasized the importance of chemical senses in host selection, but senses such as those concerned with perception of surfaces (WILLIAMS, 1954, and CALLAHAN, 1957) may also be of importance.

TABLE I

Number of thrips found on 20 seedlings of the five tested cotton varieties.

Date in 1958	Giza 30		Menoufi		Pubescent		Semi-Pub.		Curly	
	Adult	Nymph	Adult	Nymph	Adult	Nymph	Adult	Nymph	Adult	Nymph
2 April	9	87	3	57	3	33	1	61	3	78
5 "	—	209	—	149	—	190	—	84	—	238
7 "	2	179	—	138	—	130	—	156	2	178
23 "	66	—	51	—	91	—	60	—	69	—
27 "	14	48	18	70	42	60	41	65	50	95
29 "	4	44	11	188	9	190	7	136	81	220
1 May	3	150	1	110	9	169	7	181	12	306
3 "	1	71	2	31	10	100	5	156	7	116
7 "	12	82	16	89	12	89	9	121	15	97
10 "	3	8	2	—	15	34	12	44	16	8
13 "	—	1	1	3	5	19	3	28	2	13
17 "	1	6	5	7	6	6	2	5	8	8
20 "	—	2	—	8	8	21	—	1	3	22
24 "	—	6	—	—	8	26	4	30	3	24
Cases of severe thrips infestation (average of 5 or more thrips per leaf)	5		5		7		7		7	

In the northern region of the Delta where thrips infestation is very severe GHABN (1948) has found that resistance to thrips infestation among the different cotton varieties can be arranged as follow: Sakel, Sakha 4, Marad, Bahteem, Giza 12, Giza 7, Giza 26. The Ashmouni variety was suspected by this author to be more resistant than the long fibre varieties.

The seedlings of the five tested varieties were capable of overcoming the thrips attack once they were able to shoot the first four leaves. In many cases thrips attack caused defoliation of the cotyledons and dwindled the first two leaves, but most of the infested seedlings were able to recover and catch up with other plants that were less infected. This supports the view of WILLCOCKS (1937) that some seedlings which have lost their cotyledons through thrips attack, are able to produce new leaves, either on the main stem, if the terminal buds are not injured, or on the lateral branches, if the terminal buds are destroyed.

(2) The cotton leaf-worm (*Prodenia litura* F.)

(a) Concerning the egg-laying :

Infestation with the cotton leaf-worm during the season of 1958 was not severe. The number of egg masses per acre in Bahteem area did not exceed more than 500 masses during the June generation. Thus, the difference in the number of egg masses laid on the tested varieties could not be taken as evidence of certain host preference. On the other hand, it was not possible to draw additional evidence through capturing the moths in cages to enforce them laying egg masses on the leaves of the tested varieties. Captured moths have the tendency to be indiscriminating in the matter of laying their eggs.

The number of egg masses that were discovered in the different plots of the test during June and July shows that the tested varieties can be arranged, according to egg laying attraction, as follows: Giza 30 (50) semi pubescent (32), Menoufi (24), pubescent (23) and curly leaf (8) respectively (Table II). Such a result needs

TABLE II

*Counts of the egg masses of Prodenia litura found
in the areas of the tested varieties.*

Date in 1958	Giza 30	Menoufi	Pubescent	Semi pubescent	Curly
2 June.....	32	16	10	17	2
3 ".....	7	5	5	4	3
4 ".....	5	1	2	2	—
5 ".....	3	—	—	1	—
12 ".....	—	—	1	2	—
22 ".....	1	—	—	2	—
1 July.....	—	—	1	1	1
2 ".....	2	1	2	1	1
3 ".....	—	1	1	1	—
8 ".....	—	—	—	—	1
14 ".....	—	—	—	1	—
25 ".....	—	—	1	—	—
Total.....	50	24	23	32	8

confirmation by carrying out the test under a higher degree of infestation. Nevertheless, the above arrangement can be explained. Giza 30 was most liable to egg-laying owing to the high level of plants and that its leaf surface is flat globulous, wide and the edge notches are shallow. This agrees with the finding of BISHARA (1947) who found that Giza 30 harboured the maximum number of *Prodenia* egg masses, while Menoufi contained the least number. The next preferred variety is

the semi pubescent the plants of which are vigorous and high, the leaves are broad and tender and the layer of hair is not too thick. The medium density of egg masses was laid on Menoufi, which has shorter plants and smaller leaves, also on the pubescent which has a thick layer of hair on the lower surface of leaves. The least density was found on the curly leaf variety, the plants of which are the shortest and the leaves very small and curly. In some cases the egg batch did not stick to the surface of the curly leaf and most of the eggs fell down to the ground before hatching.

(b) *Concerning the damage of larvae:*

Owing to the slight degree of infestation by the cotton leaf-worm at the time of the test, all results obtained in relation to the damage of larvae on the five tested varieties had to depend on observations about enforced infestation by larvae introduced to covered plants in the field or by offering the leaves of the tested varieties to the larvae in breeding cages. Contrary to the moths, caterpillars have definite chemotropic response which leads them to certain preference of hosts, even under captivity condition.

The first and second instar larvae did not show any preference to certain leaves of the tested varieties. They were able to nibble on the lower surface of the leaves of the five varieties. The third instar larvae and older ones showed definite preference for consuming leaves of Giza 30, Menoufi and curly varieties than for the pubescent and semi pubescent varieties. When the grown larvae were offered a choice, they consumed the globulous leaves quite readily, while the pubescent leaves were hardly touched, or contained only a few small holes. When the globulous leaves were exhausted in the breeding cage, the larvae began to consume the pubescent leaves. In most cases, the small curly leaves were more severely attacked than those of Giza 30 or Menoufi. When *Prodenia* larvae were introduced to covered pubescent plants they attacked the leaves and other parts quite readily.

(3) **The pink bollworm (*Pectinophora gossypiella* Saunders)**
and the spiny bollworm (*Earias insulana* Boisd.)

These two bollworms infest the cotton bolls from June till October. In most areas of Egypt the number of the pink bollworms that are found in the cotton bolls greatly exceeds that of the spiny bollworms. Comparison of damage is usually related to the number of larvae of the two kinds found in a certain number of bolls. In the present work it was found that the number of the pink bollworms reaches 5 to 10 times that of the spiny bollworms, by inspecting 20 bolls at short intervals during August to October. To the author's view this method of estimation is quite misleading, especially in connection with the damage caused by *Earias insulana*. At the beginning, the spiny bollworm tunnels through the terminal shoots and eventually destroys them. As soon as the cotton plant bears squares and more developed flower-buds the spiny bollworm attacks these parts in preference to the

shoots. Damaged terminal shoots will be found in May and June. In the present work, inspection revealed that a great number of dead terminal shoots appeared during September and October. During that time the spiny bollworm attacked also the stalks of the squares and flower buds. WILLCOCKS (1937) observed that a spiny bollworm may commence feeding in a terminal bud, a shoot, or a square and finally complete its growth in a boll. At present the author, with the collaboration of Mr. A. A. MABROUK is indulged in estimating the real damage caused by the spiny boll-worms to the terminal shoots during the whole season.

Number of the spiny bollworms (Table III) in the bolls of the pubescent cotton was double that found in the same number of bolls of the other three globulous varieties. Three reasons may be thought of as responsible for the abundance of spiny bollworms in the bolls of the pubescent variety; that the moths may be more attracted to lay their eggs on these bolls, that the caterpillars may be more liable to migrate and to infest such bolls, or that the bolls being larger than in case

TABLE III

Number of spiny bollworms, Earias insulana, that were found in 20 bolls.

Date in 1958	Giza 30	Menoufi	Pubescent	Semi pubescent	Curly
4 August	—	—	2	—	—
7 "	—	—	1	—	—
10 "	—	1	1	2	—
12 "	1	—	—	2	—
14 "	1	2	2	3	—
17 "	—	—	1	2	—
19 "	1	—	1	—	1
23 "	—	—	—	2	—
25 "	—	—	—	—	—
27 "	3	6	2	3	1
30 "	—	2	3	2	1
1 September	—	—	2	4	1
3 "	1	—	3	4	2
6 "	2	—	1	—	2
8 "	3	3	2	4	4
10 "	1	2	3	4	3
13 "	2	—	5	6	1
15 "	3	1	4	3	—
23 "	3	2	4	2	3
2 October	2	1	—	1	—
4 "	2	2	—	1	—
Total	25	22	37	45	19

of other varieties can harbour more larvae than in case of smaller bolls. The real cause may be ascertained on further investigation. Also the twig damage should be incorporated with the boll damage before determining any host preference of this pest.

The difference in the number of the pink bollworms that were found in the bolls of the five tested varieties was not of any significance, except in the case of Giza 30 the bolls of which contained the least number of larvae (Table IV). This result is contrary to the finding of BISHARA (1947) when he estimated the damage in the bolls of three successive cultivations and found that the bolls of Giza 30 were the most susceptible to infestation with the pink bollworms, followed by Karnak then Menoufi and Ashmouni.

TABLE IV

*Number of the pink bollworms (Pectinophora gossypiella)
that were found in 20 bolls.*

Date in 1958	Giza 30	Menoufi	Pubescent	Semi pubescent	Curly
4 August	—	—	—	3	2
7 "	—	1	2	—	—
10 "	2	2	—	—	1
12 "	1	2	3	1	1
14 "	3	1	4	2	2
17 "	2	1	2	4	3
19 "	1	5	5	3	1
23 "	6	10	11	5	3
25 "	5	6	8	7	6
27 "	8	17	5	14	6
30 "	13	29	28	26	15
1 September	15	15	19	19	55
3 "	20	28	22	34	25
6 "	9	15	19	29	20
8 "	9	15	25	22	13
10 "	10	22	15	20	21
13 "	9	13	16	20	22
15 "	19	14	12	17	18
23 "	6	15	14	12	16
2 October	7	14	4	3	6
4 "	4	7	—	2	2
Total	149	232	214	243	238

As for the percentage of infested bolls, the five tested varieties stand on the same footing, having slight differences of insignificant value.

(4) The cotton aphid *Aphis gossypii* G.

Inspection of the cotton leaves for the symptom of aphid damage and number of insects started from the beginning of August until the end of September when the infestation declined and came to an end at the beginning of October (Table V). The curly leaves proved to be the most susceptible to the aphid infestation among the tested varieties. Such preference persisted throughout the whole period of infestation.

TABLE V

Counts of aphid infested leaves among a hundred inspected leaves of each tested variety.

Date in 1958	Giza 30	Menoufi	Pubescent	Semi pubescent	Curly
6 August	10	10	18	22	38
9 " "	8	13	20	21	50
12 " "	9	7	21	7	14
16 " "	8	7	15	10	20
19 " "	4	5	17	14	33
23 " "	5	5	42	16	24
25 " "	3	2	39	10	25
28 " "	—	6	12	12	14
31 " "	—	6	7	5	9
3 September	3	8	3	8	16
6 " "	—	5	5	3	24
9 " "	4	5	25	21	* 10+27
13 " "	5	6	20	15	30
16 " "	4	5	14	7	* 45
20 " "	3	—	6	5	21
23 " "	2	7	3	7	25
2 October	—	—	—	—	—
4 " "	—	—	—	—	—
Total	68	97	267	183	426

*Severely infested leaves

The curly surface of the leaf is a definite reason for more susceptibility to aphid infestation. Aphid insects prefer, especially when feeding, to be in a stereokinetic state, i.e. to lay most of their sense organs and body wall in touch with the surface on which they are standing. That is why these tiny insects are usually found in crevices and folds or in the corners of the leaf veins. One of the main symptoms of aphid infestation is curling of the leaf surface or formation of galls as a reaction to the feeding of these insects. Thus, curly leaves seem to be more suitable for the insects to aggregate all over the leaf surface.

The order of susceptibility to aphid infestation among the other four varieties is as follows: Pubescent, semi-pubescent, Menoufi and Giza 30, respectively. The hair over the leaf surface seems to act as a favourable character more than as an obstacle for the infestation of aphids. Giza 30 was remarkably less infected with aphids than the other four varieties of cotton. According to SOLIMAN (1947) the Saklaridis variety was more susceptible to aphid infestation than Ashmouni or Giza 7.

(5) The red mite (*Tetranychus telarius*) complex

Spider mites that are found on cotton leaves during summer are of different species that belong to three families. *Tetranychus telarius* is the most important of them and starts its infestation on the cotton seedlings in March and continues in different densities until the end of the crop in September (EL-BADRY, 1959).

Susceptibility to the infestation with the red mite was quite different among the tested varieties of cotton. The curly leaf cotton was, as in case of aphid infestation, the most susceptible to the red mite infestation. The factor that is responsible

TABLE VI

Counts of red mite infested leaves among a hundred inspected leaves of each tested variety.

Date in 1958	Giza 30	Menoufi	Pubescent	Semi pubescent	Curly
6 August	38	60	10	28	55
9 "	19	36	—	10	42
12 "	12	31	4	28	42
16 "	50	50	9	21	70
19 "	13	33	2	10	27
23 "	47	48	—	57	62
25 "	42	66	—	45	54
28 "	22	58	16	50	78
31 "	29	61	11	32	49
3 September	44	66	14	40	85
6 "	50	65	20	49	78
9 "	65	80	15	33	85
13 "	35	45	8	32	65
16 "	63	73	8	30	82
20 "	69	77	31	69	80
23 "	71	81	33	69	86
2 October	100	100	97	100	100
4 "	100	100	100	100	100
Average percentage of red mite infestation until end of September	41.8	58.12	14	37.87	65

for such preference in case of the red mite is quite different than in the case of the aphid infestation. The proboscis of the mite is of the prognathos type as the mouth parts lie in a straight line with the head of the spider mite. This means that the mite should take a vertical position to be able to insert its proboscis into the leaf tissue. Thus, the curly surface becomes more suitable for the feeding process and consequently more favourable for the propagation of the mites. Menoufi came next to the curly leaf cotton in the sequence of susceptibility and the reason may be related to the rather tender tissue of the leaves. Resistance to the infection was clearly shown in case of the pubescent leaves and this may be due to the thick layer of hair that may obstruct the feeding of mites.

At the beginning of October most of the leaves of the five tested varieties were infested with spider mites, but severe cases were kept according to the above-mentioned sequence (Table VI).

(6) Drying and shedding of the cotton bolls.

Cotton bolls may dry off or be shed during any stage of their development due to several factors, the most important of which is insect and spider mite attack. According to SAMI (1954) the boll shedder bug *Creontiades pallidus* Ramb. is the most serious insect to cause shedding of the cotton flowers and bolls; 25.5% in case of the flowers and 22.9% in case of the bolls. Feeding of *Creontiades* in green bolls has an obvious bad effect; it causes the shedding of the three day-old, or less, bolls; the older bolls which do not shed, are badly affected; on older bolls the insect prevents the small seeds from growing and consequently no hairs grow or, if some are existing, they will be dead. The latter author claims that this insect did not show any preference for a certain variety of cotton.

Dry and shed bolls on the whole number of plants of the five tested varieties were counted twice; the first time at the beginning of September (after the first picking) and the second time at the beginning of October (after the second picking). Records (Table VII) indicate that the curly leaf cotton was the most susceptible

TABLE VII

Dry and shed bolls on the plants of the tested varieties.

Variety	Number of plants	Number of dry bolls after first picking	Number of dry bolls after second picking	Average number of dry bolls per plant
Giza 30	2603	203	1079	0.40
Menoufi	2392	201	1383	0.57
Pubescent	710	266	882	1.01
Semi-Pubescent	968	265	990	1.02
Curly	1556	355	2422	1.50

variety to dryness and sheeding of bolls followed by the pubescent and semi pubescent varieties. Giza 30 and Menoufi carried the least number of dry bolls. On some plants of the curly leaf cotton more than 25% of their bolls were small and dry.

(7) The yield of cotton wool and seeds.

As in the case of all crops, the yield is influenced by different factors that affect the growth of plants during the whole period of cultivation, whether it is cultural, genetical or pathological conditions. As the five tested varieties received the same cultural practices, so the differences in the yield can be related to either genetical or pathological reasons. Owing to the fact that the number of plants in each tested variety differed considerably, it became necessary to find out the average yield per plant of each variety. Seven hundred and ten plants of the pubescent cotton yielded 19,960 kilograms of unginned cotton wool. This makes an average yield of 28 grams of cotton wool and seeds per plant. The semi-pubescent cotton gave an average of 20 grams, Giza 30 gave 12.7 grams, Menoufi 11.7 grams and the curly leaf 11.2 grams (Table VIII). This means that the pubescent and the semi-pubescent

TABLE VIII

The yield of the cotton wool of the five tested varieties.

Variety	Number of plants	First picking	Second picking	Yield per plant
		<i>kgs.</i>	<i>kgs.</i>	<i>grams.</i>
Giza 30	2603	30.365	2.595	12.7
Menoufi	2392	25.795	2.125	11.7
Pubescent	710	17.180	2.770	28.0
Semi-Pubescent	968	21.475	3.090	25.3
Curly	1556	15.030	2.405	11.2

varieties gave higher yield per plant than the other tested varieties. In spite of the fact that all the tested varieties were cultivated in an area of the same size yet the number of plants of each variety varied considerably. Accordingly, space between plants differed from one variety to the other. The area of Giza 30 was the most crowded, followed by that of the Menoufi, then the curly, the semi-pubescent and the least crowded area was that of the pubescent variety. If the yield of the whole area of each variety is considered, the yield sequence becomes as follows: Giza 30 (32.960 kilos), Menoufi (27.920 kilos), Semi-pubescent (24.565 kilos), pubescent (19.950 kilos) and lastly the curly leaf (17.435). In both cases of estimation, the curly leaf cotton gave the least yield among the tested varieties.

IV. SUMMARY

(1) Five varieties of cotton plants — three of them acquire wild characteristics and the other two are of the present cultivated varieties — were tested for susceptibility to infestation with insects and spider mites.

(2) Infestation with *Thrips tabaci* Lind. was nearly of the same level among the tested varieties.

(3) The cotton leaf worms *Prodenia litura* F. consumed the curly leaves quite readily. They were not attracted to pubescent leaves unless forced as under captivity.

(4) There was no clear difference in respect to infestation with the spiny and the pink boll worms.

(5) Infestation with *Aphis gossypii* Glover was more severe on the curly leaves and the pubescent leaves and less severe on Giza 30.

(6) The curly leaves were the most susceptible to the infestation with the red mites *Tetranychus telarius* complex followed by Menoufi. The pubescent leaves were the least susceptible.

(7) The curly leaf cotton was also the most susceptible to the phenomenon of dry and shed bolls followed by the pubescent cotton. Percentage of such bolls was higher on the mentioned varieties than on Giza 30 and Menoufi.

(8) The yield of cotton wool and seeds whether in the whole plot or as average per plant was lowest in the case of the curly leaf cotton.

(9) The present test has shown that the curly-leaf cotton was more susceptible to the attack of the cotton-leaf worms the aphids and the red mites and its bolls were more liable to turn dry and be shed more than the other tested varieties. On the other hand the pubescent cotton was more susceptible to the attack of aphids and its bolls more liable to turn dry and be shed than the globulous varieties Giza, 30 and Menoufi but it was less susceptible to the attack of the cotton leaf-worms and the red mites.

V. ACKNOWLEDGMENT

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ANTAGONISTIC EFFECT OF CHLOROFORM ON ETHERIZED *MUSCA DOMESTICA VICINA*

[*Diptera: Muscidae*]

(with 1 Text-Figure and 4 Tables)

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CONTENTS

I. Introduction. — II. Procedure. — III. Temperature and the anesthetic effect of ether. — IV. Temperature and the anesthetic effect of chloroform. — V. Effect of chloroform on ether stupefied flies. — VI. Effect of ether on chloroform stupefied flies. — VII. Summary. — VIII. Bibliography.

I. INTRODUCTION

When insects are exposed to the fumigant vapour they first show signs of agitation, becoming excited and restless. They respond to the effect of the anesthetic by struggling violently, kicking their feet and fluttering their wings. At the end the insect becomes stupefied and motionless, usually lying on its back. The period of exposure to the fumigant that passes until the insect is "knocked down" is taken as the stupefaction period. If the insect is removed from the fumigation chamber soon after being stupefied, it may recover after a while. The recovery period depends on the concentration of the fumigant, i.e. anesthetic, temperature and period of exposure. If and when any of these factors exceeds its critical limit, the insect may never recover, and dies.

The present work deals with the anesthetic effect of both ether vapour and chloroform vapour on the Levant house fly, *Musca domestica vicina*. The flies were exposed to the vapour of each fumigant under different degrees of temperature

and then successively in both ways, i.e. etherized flies to be subjected to chloroform vapour and chloroform stupefied flies to be exposed to ether vapour.

In a previous work (ABOUL-NASR, 1953), the author has tried the effect of carbon tetrachloride on etherized *Drosophila virilis*. It was indicated that carbon tetrachloride has an antagonistic effect on etherized *Drosophila* flies. Having in mind such a result, it was of interest to try the effect of chloroform on etherized flies as an additional investigation into the anesthetic effect of fumigants on the insect.

II. PROCEDURE

Musca domestica vicina flies were used as test insects. These flies could be newly emerged up to several days old. The milk method (HAFEZ, 1948) was mainly used in rearing the adult flies needed for the experiments. The fumigation chamber was a wide glass tube 15 cms. long and 5 cms. wide. The top end of the tube was tightly closed with a cork stopper with a passing through thermometer. The lower end of the tube is fitted with a fine wire gauze septum at the level of 4 cms. from

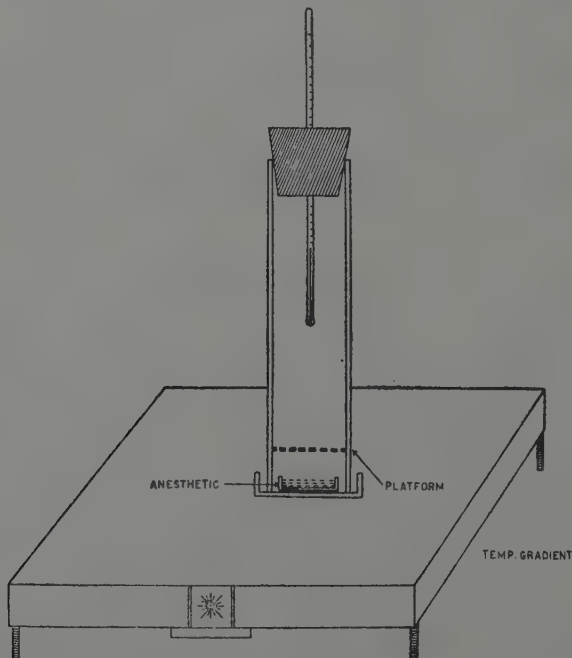


FIG. 1: Chamber of anesthesia

the edge to support the bodies of the "knocked down" flies and prevent them from drowning in the liquid anesthetic.

The anesthetic, whether ether or chloroform in liquid form, is provided in a small round container to be placed under the lower end of the fumigation tube. The same container has been used throughout the experiments in order to standardise the evaporating rate of the anesthetizing fluid. There was no need to measure the total concentration of any one anesthetic used in the tests since it is the study of the correlation between their effects that is needed and not the relation between the actual dosage of the anesthetic and the recovery time. The only point of control that was taken in these tests besides that of temperature was time of exposure.

In order to get the variation in temperature required for these tests, the fumigation chamber was placed upon a flat temperature gradient that could be regulated to give the required temperature.

Before running the test to record the effect of the anesthetic upon the insects, the group of flies were introduced into the fumigation chamber placed upon the temperature gradient, allowed to settle until the required temperature was recorded and stabilized before the container with the anesthetizing fluid was introduced. After running the tests of exposure, the container with the anesthetic was taken away and the fumigation chamber containing the "knocked down" flies was raised on supports to allow aeration of the chamber under the same temperature conditions. The upper end of the chamber is left open for some time until some flies show signs of recovery and hence both ends of the chamber are securely covered by muslin or wire gauze.

The recovery time of 50 per cent of the group under test is taken as an average for the test conditions under study. The stupefaction period of about 50 per cent of the flies is also taken as average for the test group. A supply of water was always presented to the recovering flies to eliminate the factor of water loss during the 24-hour period of observation to get the per cent of total recovery. The flies were usually left overnight at room temperature.

III. TEMPERATURE AND THE ANESTHETIC EFFECT OF ETHER

Groups of thirty flies were exposed to the ether vapour, under five degrees of temperature, 20, 25, 30, 35 and 40°C. Time of exposure under each degree ranged between 30 seconds and two minutes. Table I shows that the stupefaction period becomes shorter as the temperature increases. Such effect is expected in all the fumigants due to the fact that raise of temperature causes increase in the gas volatility and its quicker penetration inside the tissues. As the period of exposure lengthens, under the same temperature, the period of recovery extends accordingly and the percentage of recovery after 24 hours decreases. It is noticed that the recovery time under the temperatures of 20 and 40°C. was longer than under the temperatures

of 25, 30 and 35°C. Also the percentage of recovery was the least under the temperatures of 20 and 40°C. than under the other three tested degrees of temperature. This means that under the low temperature of 20°C. ether is more liable to be retained in the tissues, thus causing longer period and lower percentage of recovery. On the other hand the high temperature of 40°C. makes the fumigant more volatile and more effective thus causing the same symptoms, as in case of the low temperature, but in a different manner.

TABLE I

Showing the stupefaction period, the recovery period and the percentage of recovery after exposing thirty flies to the vapour of ether at different temperatures and at different periods of exposure.

Period of exposure in seconds	Period of 50% recovery					Percentage of recovery after 24 hours				
	20°	25°	30°	35°	40°	20°	25°	30°	35°	40°
30	—	12	15	12	18	—	100	100	100	96.7
45	18	14	15	14	22	96.7	100	100	100	90
60	25	18	18	15	25	100	93.4	100	100	90
75	25	18	18	18	25	90	96.7	93.4	100	93.4
90	29	22	20	19	30	76.7	86.7	90	93.4	73.4
105	32	28	26	24	33	76.7	90	86.7	83.4	66.7
120	45	35	35	33	36	56.7	70	80	73.4	53.4
Stupefaction period in seconds.	40	30	30	25	22					

IV. TEMPERATURE AND THE ANESTHETIC EFFECT OF CHLOROFORM

The same tests were carried out with the use of chloroform instead of ether, and the result is shown in Table II. In the case of chloroform it was observed that under the low temperature of 20°C. the recovery time, after 60 seconds of exposure, was shorter than under the other four warmer tested degrees of temperature. Also the percentage of recovery was the highest under the low temperature. This means that under low temperature the toxicity of chloroform vapour is rather slow.

Otherwise chloroform vapour caused longer period and lower percentage of recovery than ether vapour did under the warmer degrees of 25, 30, 35 and 40°C. Also the stupefaction period under 30, 35 and 40°C. was slightly shorter in case of chloroform than in case of ether. This suggests that chloroform vapour is comparatively more toxic and thus more effective than ether vapour.

TABLE II

Showing the stupefaction period, the recovery period and the percentage of recovery after exposing a group of thirty flies to the vapour of chloroform at different temperatures and at different periods of exposure.

Period of exposure in seconds	Period of 50% recovery per minute					Percentage recovery after 24 hours				
	20°	25°	30°	35°	40°	20°	25°	30°	35°	40°
30	—	8	14	18	10	—	100	100	96.7	90
45	18	18	20	20	18	100	90	100	96.7	96.6
60	20	30	27	30	28	100	93.4	96.7	96.7	83.4
75	25	35	32	32	37	96.7	80	90	90	70
90	28	38	38	45	50	96.7	80	80	80	73.4
105	30	42	42	49	52	90	66.7	73.4	73.4	66.7
120	35	45	48	56	59	93.4	60	66.7	53.4	56.7
Stupefaction period ..	40	30	25	20	20					

WEBB in 1945, found that increasing temperature also enhances the action of nicotine and derris in *Melophagus*. He also stated that the rate of entry of an insecticide depends upon temperature, the structure of the respiratory spiracles and the metabolic state of the insect (WEBB, 1949). EDWARDS and NUTTING, in 1950, claimed that the temperature at which the maximum rate of oxygen consumption is reached, before heat inactivation becomes apparent, varies considerably. For example, *Thermobia domestica* reaches its maximum oxygen consumption at 51.3°C., whereas the respiration of *Grylloblatta* is maximum at 20°C.

The effect of temperature on the respiration of the insect depends in part on the stage of development. ARGO (1939) proved that in the egg of the milk weed bug, *Oncopeltus fasciatus*, the maximum respiratory rate is reached at a lower temperature than in the adult. BIRCH (1947) found that in *Rhizopertha* the effect of temperature is the same in both larvae and adults but in *Calandra* the larval respiration is accelerated to greater extent than that of the adult with increasing temperature. The spiracles are forced open by high temperatures as in the presence of carbon-dioxide and this was supported experimentally by HAZELHOFF (1926), BUXTON (1930), GUNN (1933), MELANBY (1935) and WIGGLESWORTH (1939).

V. EFFECT OF CHLOROFORM ON ETHER STUPEFIED FLIES

After realising the different characteristics of the ether and chloroform vapours in connection with their toxicity at different periods of exposures, fresh groups of 30 untested flies were exposed first to the ether vapour for one minute,

to ensure the knock down of the whole group; then the stupefied flies were exposed to the vapour of chloroform for different periods ranging from 20 to 120 seconds. Fumigation took place under the low temperature of 20 and the high temperature of 40°C.

TABLE III

Showing period and percentage of recovery for 30 ether stupefied flies exposed to chloroform vapour for different periods at 20 and 40°C.

Period of exposure in seconds	Period of 50% recovery per minute		Percentage of recovery after 24 hours	
	20°	40°	20°	40°
20	25	25	96.7	83.4
45	18	15	96.7	90
60	8	6	100	100
75	7	10	100	100
90	20	28	70	70
105	30	37	76.7	56.7
120	35	45	56.7	53.4

If period and percentage of recovery in Table III are compared with those in Table I, some points of interest can be deduced. When the ether stupefied flies, were exposed to chloroform vapour for 60, 75 and 90 seconds, period of recovery became clearly shorter than in the case when insects were exposed to ether vapour alone. Exposure to chloroform vapour for 60 and 75 seconds caused complete recovery for the ether stupefied flies under the two tested degrees of 20 and 40°C. Longer periods of exposure to chloroform vapour caused retreat to the antagonistic effect.

The explanation for such phenomenon could be presented in that chloroform vapour with its high volatility and perhaps its greater liability to be dissolved inside the tissues reaches a concentration that opposes the anesthetic effect of ether. This antagonistic effect causes the flies to recover in a shorter time. In case of flies that were exposed to ether vapour for 60 seconds at 20 and 40°C., the recovery period was 25 minutes. When the ether stupefied flies were immediately exposed to chloroform vapour for 60 seconds they recovered after only 8 minutes under 20°, and after 6 minutes under 40°C. When the etherised flies were exposed to chloroform vapour for 75 seconds under 20 and 40° the period of recovery became 7 and 10 minutes respectively, instead of 25 minutes in case of ether alone. When the period of exposure to chloroform vapour was extended to 90 seconds, the difference in the period of recovery was lessened, reaching 20 minutes instead of 29 (under 20°) and 28 minutes instead of 30 (under 40°). If the exposure period

to chloroform vapour were extended to 120 seconds, the correlation between the periods of recovery was reversed under 40° (becoming 45 minutes in case of double exposure instead of 36 minutes in case of ether exposure alone) and became closer under 20°C. (35 minutes in case of double exposure and 45 minutes in case of ether exposure alone). Long period of exposure to chloroform vapour permits the excess to take over the anesthetic effect after antagonizing the ether effect.

VI. EFFECT OF ETHER ON CHLOROFORM STUPEFIED FLIES.

After testing the effect of chloroform on ether stupefied flies, it became necessary to treat other groups of fresh flies in a reverse way, i.e. to fumigate the flies first with chloroform and then to expose the stupefied flies to the ether vapour.

TABLE IV

Showing period and percentage of recovery in groups of 30 chloroform stupefied flies exposed to ether vapour at 20 and 40°C.

Period of exposure in seconds	Period of 50% recovery per minute		Percentage recovery after 24 hours	
	20°	40°	20°	40°
20	40	40	56.7	33.4
45	40	45	53.4	23.4
60	45	58	50	28.8
75	45	62	50	16.7
90	50	68	33.4	6.7
105	65	No recovery	28.8	No recovery
120	68	No recovery	28.8	No recovery

If the result of the reversed double exposure in Table IV was consulted and compared with its respective in the other three previous tables it asserts the relation between the effect of chloroform vapour and ether vapour from the standpoint of the anesthetic reaction on the insect tissues, and perhaps on other animal tissues. Chloroform ether double exposure caused remarkable extension of the recovery period, reaching in many cases double or triple the period of single exposures, whether the agent was ether or chloroform. Exposing ether stupefied flies to chloroform vapour showed an antagonizing effect, thus shortening the recovery period and increasing the percentage of recovery. But exposing chloroform stupefied flies to ether vapour gave a depressing effect, lengthening the recovery period and decreasing the percentage of recovery to the extent that the whole group of the treated flies died. It is quite evident that access of ether adds to the toxicity previously caused

by the chloroform. It is a matter of the agent stability inside the tissue. There seems no doubt, according to the result of the present work, that chloroform is a more stable agent inside the insect tissue than ether.

VII. SUMMARY

(1) Groups of 30 *Musca domestica vicina* flies were fumigated with ether vapour at different temperature and for different periods of exposure. Other groups of flies were similarly subjected to the vapour of chloroform.

(2) Stupefaction period is inverse correlation with temperature at time of fumigation.

(3) Period and percentage of recovery depend on temperature and extent of exposure. In case of ether, fumigation under the low and high temperature caused longer period and lesser percentage of recovery than the medium degrees of temperature. But in case of chloroform the anesthetic effect increases in correspondence with the increase of temperature and extension of exposure.

(4) Successive exposure to chloroform following ether causes antagonistic effect of the anesthesia. The recovery period becomes shorter and the percentage of recovery becomes higher. Longer exposure to chloroform vapour causes the antagonistic effect to retreat.

(5) Successive exposure to ether following chloroform adds to the anesthetic effect. The recovery period becomes longer and the percentage of recovery becomes lower.

(6) It is quite possible that chloroform is more stable inside the insect tissues than ether. Access of chloroform to the etherised flies decreased the anesthetic effect. Access of ether to the chloroform stupefied flies increased the anesthetic effect.

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ENZYMOLOGICAL STUDY OF THE VENOM OF *POLISTES OMISSA* WEYR.

[*Hymenoptera : Vespidae*]

(with 1 Text-Figure)

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INTRODUCTION

Components of high biological activity in Hymenoptera venoms are considered by NEUMANN and HABERMANN (1956) as "histamine, 6-hydroxytryptophane, acetylcholine, proteins with non specific enzyme action and enzymes". From the enzymes, phospholipase A was found in bee venom by NEUMANN and HABERMANN (1954) and by GRASSMANN and HANNING (1954). The antigenic nature of this enzyme was proved by EL-KARIMI (1957). A hyaluronidase was also found, by CHAIN and DUTHIE (1940) and by HABERMANN (1957) in bee venom and by JAKES (1956) in the venom of *Apis mellifera* and *Vespa vulgaris*. The antigenic nature of the hyaluronidase of bee venom was also proved by EL-KARIMI (1957).

No mention was ever made to the occurrence of peptidases in venoms of Hymenoptera although coagulation of blood was found to take place by bee venom (HABERMANN and NEUMANN, 1954). Neither has the effect of venom of Hymenoptera on esters including cholin esters been investigated. The presence of acetylcholine in the venom itself (NEUMANN and HABERMANN, 1956) makes the presence of cholinesterase improbable, on the other hand this enzyme occurs frequently in venoms of some snakes (ZELLER, 1948).

In the present work the hyaluronidase, peptidase and esterase content of the venom of *Polistes omissa* Weyr. was investigated.

MATERIAL AND METHODS

The insects were collected from villages in the vicinity of Cairo and were kept in the laboratory in well aerated boxes. Narcotization was carried out by chloro-

form and the stinging apparatus of each animal was dissected free from the neighbouring hind-gut under the binocular. The isolated stinging apparatus is composed of the sting itself and the adjoining alkaline and acid glands. This whole complex was washed, dried superficially, weighed and ground in a mortar. Extraction took place with distilled water in the ratio 10cc. water for every gram material, overnight in a refrigerator (4°C.). Toluene was added as antiseptic. Before use the required dilution was obtained by adding distilled water.

The methods used in the preparation of the substrates and in the estimation of enzyme activity are similar to those in a previous investigation (SAID, 1960).

RESULTS

1. Hyaluronidase

Measurements of hyaluronidase activity was made on samples from a mixture containing in one cc. 200 µgm hyaluronic acid, 0.2 cc. (1:40) extract of the sting in 0.2 molar phosphate buffer of varying pH, both before and after 30 minutes incubation at 37°C. The results show that hyaluronidase is present in the venom of *Polistes* is active over the pH range 3 to 8.5 and shows optimal activity at pH 5.6. The only data available for the pH optimum of hyaluronidase in the venom of Hymenoptera are those of HABERMANN and NEUMANN (1954) who found for hyaluronidase of bee venom an optimal pH at 4.0 when its activity was measured reductometrically and at 5.0 when measured viscosimetrically.

When NaCl in concentrations ranging from 0.05 to 0.25 molar was added to the mixtures, no activation was found to take place contrary to the case for hyaluronidase of other sources (see SAID, 1958). The non effect of NaCl on the action of hyaluronidase of *Polistes* venom may be due to the full activation of the enzyme by the phosphate ions of the buffer used: a similar finding had been previously recorded by HABERMANN (1957) for bee venom hyaluronidase.

A linear relationship was found between the amount of enzyme and the extent of splitting of the hyaluronic acid. Such a relationship had been also found for hyaluronidase of other sources (FISHMAN, 1951; SAID, 1958). This relationship enables the calculation of the amount of enzyme per cc. of the extract and it could be calculated that 1 mg of the extracted sting contains 1.15 I.U. at the optimal pH 5.6. As the average weight of *Polistes* sting was found to be 1.2 mg., it would appear that *Polistes* sting is charged with about 1.34 I.U.

2. Peptidases

0.3 cc. of extract of *Polistes* sting (1:10) did not cause any splitting of either gelatin, fibrin, leucylglycine, chloracetyl-L-tyrosine or leucylglycine at different H ion concentrations over the pH range 3 to 8 and even after 6 hours incubation at 37°C. It can be concluded therefore that the venom of *Polistes* is devoid of pepti-

dases. Further experiments are till necessary to investigate the effect of this venom on blood coagulation. Some venoms are known to induce thrombosis while they were found free of peptidases (RIAD, 1957-1958; SAID, 1958; SAID, 1960).

3. Esterases

Negative results were obtained for the effect of *Polistes* venom on acetylcholine chloride. The amount of venom used was 0.5 cc. extract (1:20) which were left to act for two hours on 0.004 molar acetylcholine chloride in 0.2 molar phosphate buffer, the mixtures had H ion concentrations ranging from 3 to 8. It was noticed that controls containing venom gave values for actylcholine higher than blanco values, indicating the presence of acetylcholine in the venom itself.

Aliesters on the other hand were found to be split by *Polistes* venom. The results of splitting of ethylacetate, tributyrin and olive oil are presented graphically

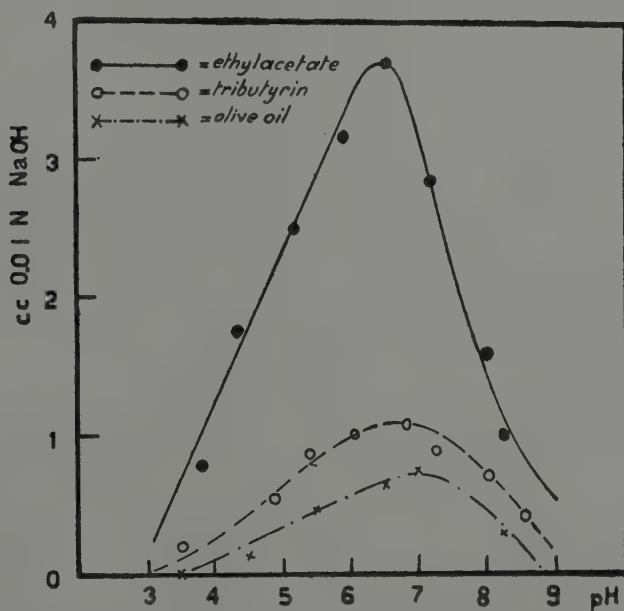


FIG. 1: Digestion of aliesters by *Polistes* venom. Titration sample: 0.7cc. extract of fresh stings (1:20) together with 0.7 cc. either 0.07 millimol ethyl acetate, 0.023 millimol tributyrin or 1% olive oil in 0.2M phosphate buffer. Incubation one hour at 37°C.

in Figure 1 from which it can be seen that the pH optima for splitting of these substrates are 6.5, 6.8 and 6.9, respectively. At these optimal pH values 0.7 cc. (1:20) extract of *Polistes* sting caused the splitting of 53% of 0.07 millimol ethylacetate

47% of 0.23 millimol tributyrin and liberated fatty acids equivalent to 0.72 cc. 0.01 N NaOH of 0.7 cc. 1% olive oil in 0.2 molar phosphate buffer after 1 hours incubation at 37°C.

SUMMARY

The presence of hyaluronidase and esterases in the venom of *Polistes* was demonstrated.

Search for endo- and exopeptidases and cholinesterase led to negative results.

ACKNOWLEDGMENT

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A NEW MUSCOID FLY FROM GEBEL ELBA

[*Diptera: Muscidae*]

(with 9 Text-Figures)

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***Musca effatouni*, n. sp.**

A small species of metallic grey thorax of 7.10 mm. in length and indistinct thoracic striping in the male and rather more distinct stripes on the thorax of the female.

MALE: Eyes bare, vertex quite narrow, approximately $1/5$ to $1/6$ of the width of an eye. Vertical stripe occupying almost the whole of the narrow vertex. Cheeks and lower part of vertex silvery white. Ground colour of the thorax metallic greyish blue with white dusting with two vertical black stripes which are rather indistinct. There are two pre-sutural dorso-centrals and two post-suturals and only one pair of acrostichal. Sternopleurals present one anterior and two posterior.

Abdomen: mainly light greyish green tinged with orange; terga 1 and 2 with a central dark band and flanked with large oval dark orange areas, rest of upper and lateral parts dark. Tergum 3 with a moderately wide T-shaped central black band which also spreads to cover a small margin of the base of the segment, sides largely silvery light blue or green in some lights. Tergum 4 with a large metallic silvery green patch. Tergum 5, entirely greyish green with the same relection showing on the other terga-legs dark brown.

FEMALE: Vertex more than half of the width of the eye, outer vertical bristles in one row only. Vertical stripe black and wide and equals nearly $3/4$ the width of the eye. Thorax with two longitudinal bands. Abdomen more grey than in the

male. Tergum 1 and 2 all dark brown or dark orange. Tergum 3 with a narrow central band without marginal spreading as in the male. Rest of third tergum as well as other terga light greyish with a metallic greenish sheen and in areas where the surface colour was rubbed off the background of the segment is deep orange. Sternites very small, the major part of the ventral surface being membranous. The sternites are very dark brown in colour or even black but the membranous part is light brown.

Antennae (Fig. 1) in both male and female, greyish black. Arista with few hairs. Four long bristles and a short one dorsally and only two long ones ventrally.

The wings are clear and the bend of M 1 and 2 is rounded and first posterior cell narrowly open.

On examination of the proboscis after clearing with caustic potash, the labellae were found to be of moderate size, the pseudotracheal channels (Fig. 2)



FIG. 1: Third abdominal segment and sparsely haired arista. — FIG. 2: Pseudotracheal channels and prestomal teeth. — FIG. 3: Ninth tergosternum. — FIG. 4: Fifth sternum. — FIG. 5: Anal cerci. — FIG. 6: Phallosome. — FIG. 7: Egg-mass removed from the ovary. — FIG. 8: Female terminalia (A, 6th tergite and sternite; B, 7th tergite and sternite; C, 8th tergite; D, 9th tergal plate; E, anal cerci). — FIG. 9: 9th sternite plate of the female.

traversing their inner surfaces are rather fewer in number than in *domestica*. In *efflatouni* there are only about 20 pseudotracheae on either side; 7 in one channel distally and 9 in another channel proximally and only four separate pseudotracheae in between, whereas in *domestica* there are from 30-32 grooves on either side. The number of the prestomal teeth is also reduced to four teeth instead of five as in *domestica*. These teeth are resting directly on the well developed prestomal sclerite, there being no tooth plate.

MALE TERMINALIA: Anal cerci (Fig. 5) with the lateral free margins with a distinct convexity, lower margin almost straight. Inner ends without distinct nipple formation. Phallosome (Fig. 6) chitinous part long with marked concavity on both sides (waisting). This part is distinctly longer than the membranous part. Posterior process of phallosome of moderate length, well expanded distally and distinctly forked terminally. The anterior part of parameres is much larger and longer than the posterior part and convex from the front bearing only bristle. The posterior part is a small plate of raised and conical shape with 3-4 clear areas bearing minute sensory spines. The basal part of the cone is chitinous and the apical is membranous. This is nearly similar in appearance to the posterior part of the paramere in *Musca vitripennis* Meig.

Fifth sternum (Fig. 4) nearly as long as broad, posterior process with few short spines apically.

FEMALE TERMINALIA (Figs. 8 and 9): Oviparous, laying non-pedicelled eggs (Fig. 7). First and second sternites of usual shape, third sternite smaller than fourth. Fifth sternite is not more than one and half as long as the fourth. Segments VI, VII and VIII progressively decreasing in length. Bristles on segments VI and VII arranged in three separate small groups, each group carrying 2-3 small bristles. Bristles on segment VIII arranged on three tubercles.

The sclerites on segment VI of the tergite are forked and well chitinised, the stem of the fork rather broader and longer than the limbs of the fork. VI sternite nearly as long as the tergite and tapering terminally. Tergites and sternite of segment VII are nearly of the same length and shape. The tergites of the eighth segment are slightly longer and broader than the corresponding sternites, though the tergites are rather expanded distally. Ninth tergal plate is broader than long, trilobed in appearance with six short stout bristles on the central median lobe only. Ninth sternite broadly oval with nearly six rows of spines, few of which are long. Anal cerci with their basal arms closely apposed to the margins of the median lobe of the ninth tergite and their globose terminal sclerites armed with marginal stout bristles of which few are much longer and more prominent than the others.

It is evident from the various characters described above that this species on terminalic characters, occupies an intermediate position between the males of the *sorbens* group of PATTON on the strength of the shape of the posterior paramere, and the females of the *domestica* group of CH' I HO (1938) on the strength of the shape of the forked sixth tergum.

The holotype and the paratype are preserved in the collection of the High Institute of Public Health (Alexandria) as well as the dissected terminalia and the head and part of the abdomen.

Musca efflatouni mihi is named in memory of its collector the late Professor HASSAN CHAKER EFFLATOUN of the Department of Entomology, University of Cairo.

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**A STUDY OF THE FEMALE TERMINALIA
OF *MUSCA VITRIPENNIS* MEIG.
AND DESCRIPTION OF THE THIRD LARVAL STAGE**

[*Diptera: Muscidae*]

(with 3 Text-Figures)

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Musca vitripennis is a widely distributed fly in the Egyptian deserts (Western, Eastern and Sinai) as well as in the villages bordering them, but adults were rarely recovered from rest houses or huts in these areas. This fly has also been reported from Southern Europe, the whole of the Mediterranean littoral, Sudan, Syria, Palestine, Iraq, Arabia, Iran and along the Indian frontier and Kashmir (PATTON). It is mainly found on and about animals in the field and about their excreta. PATTON reports that these flies readily enter trains. The adults are very annoying flies as they persistently hover round animals and humans in search of sweat.

Musca vitripennis has been described by MEIGEN in 1826, but the breeding places and the larvae were unknown till today.

The adult male can easily be recognised by its hairy eyes, dark metallic green thorax without any markings and the light orange and yellow abdomen with characteristic silvery patches. *Musca albina* Wied., which has greatly reduced dorso-central and no acrostichal bristles or sternopleurals is closely allied to *vitripennis*.

The female has bare eyes and a vertical stripe a little more than half the width of the vertex and four rows of outer vertical hairs. Its thorax is greyish blue

with some metallic sheen and four distinct dark longitudinal stripes dorso-centrals and acrostichals as in the male. Abdomen light greyish yellow or grey. It may be mistaken for a large specimen of *tempestiva* Fallen which it superficially resembles.

PATTON has studied the male terminalic characters of *Musca vitripennis* and placed it in the *sorbens* group. CH' I HO (1938) published an extensive account of "The Significance of the Female Terminalia of House-flies as a grouping Character" as a continuation of PATTON's work. Since the female terminalia of *vitripennis* were not included in the studies of CH' I HO it will not be out of place to include an account of these on this occasion of our description of its larva.

The female terminalia

(Figure 1)

First and second sternites of the usual shape. Third and fourth of nearly equal size, though the former looks a bit longer. Fifth sternite roughly triangular and nearly $2\frac{1}{2}$ times as long as the fourth.

Segments VI, VII, and VIII progressively decreasing in length. Bristles on segment VI arranged in three groups of tiny small bristles, those on segment VII arranged on conspicuous tiny tubercles one dorsally and another ventrally, each carrying three long and two short bristles on either side, on segment VIII, there is one dorsal and another ventral plate carrying bristles all along the distal margin.

Chitinised sclerites: On segment VI, the tergite is a rod-like fork, the stem about $\frac{1}{3}$ to $\frac{1}{4}$ the length of any of the limbs of the fork. The sternite is a narrow rod of the same length as the corresponding tergite. On segment VII, the tergites are elongated but the sternite is distinctly shorter. On segment VIII the tergites are distinctly longer and stouter than the corresponding sternites. Ninth sternite broad and roughly triangular plate with 3-4 rows of short strong bristles apically. Ninth sternal plate oval in shape, longer than broad and covered with several rows of long black spines. Anal cerci with bulbous lobes covered with short stout bristles. The arm of the anal cercus which is applied to the side of the tergite is longer than the terminal lobose part.

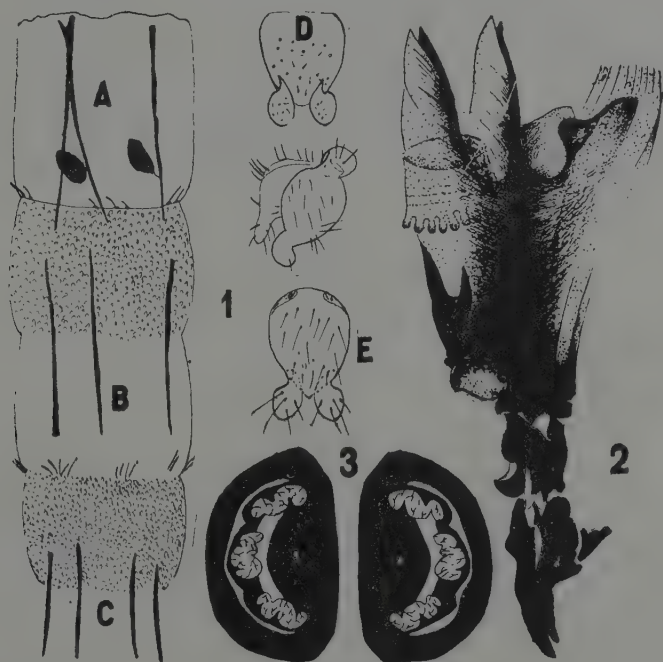
The third larval stage

This stage was the only one found in a collection of cow dung from Kerdasa (a village near the Pyramids of Giza), in 1940. Few specimens were fixed in alcohol, one specimen dissected to show the anterior and posterior ends and the rest was left to pupate and hatch to identify the adult flies.

Description: Elongate, tapering anteriorly and the dark cephalo-pharyngeal skeleton could be seen through the cuticle. Segments gradually enlarging towards the posterior end, which is bluntly rounded, and are demarcated anteriorly by rows or belts of minute spines of the muscoid type.

The cephalo-pharyngeal skeleton is the dark mass of chitin seen through the cuticle of the anterior part. The oral hooks (Fig. 2) are prominent structures

claw-like and bluntly pointed and situated just above the mouth and characteristic of the muscid larvae, the left one is slightly shorter than the right one. The basal part of the claw is well developed and thickly chitinous and with a clear area (deficient



Musca vitripennis Meig.

FIG. 1: Female terminalia (A, 6th tergite and sternite; B, 7th tergite and sternite; C, 8th tergite and sternite; D, 9th tergal plate and anal cerci; E, 9th sternal plate). — FIG. 2: Cephalo-pharyngeal skeleton and anterior spiracles of the third larval stage. — FIG. 3: Posterior spiracles of the third larval stage.

in chitin) on its ventral extension (see Fig. 2). The dental sclerite is well developed and elongate. The H-shaped hypostomal sclerite is well developed. The pharyngeal sclerite is also darkly chitinated, the dorsal cornuae longer and blunter than the shoe-shaped ventral ones. The membrane between the ventral cornuae is feebly chitinated and has 8 tubular ridges projecting into the lumen of the pharynx (Fig. 2) suggesting that the larva are of saprophagous habits feeding on decayed vegetable matter or the excrement of herbivorous animals (KEILIN, 1912) which is the case with these larva which were found in cow dung.

The anterior spiracles possess 9 short finger-like openings. In the posterior spiracles (Fig. 3) the peritreme is thick and dark and separated by a tiny clear space from the inner chitinous border which surrounds the three sinuous spiracular slits. The button is an elongate clear slit situated within the inner extension of the peritreme. The two spiracular plates are separated from each other by less than one third of the width of the plate.

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Same as recorded in our previous paper entitled "A new muscoid fly from Gebel Elba", published in this Bulletin, pages 171-174.

ANALYSIS OF THE RELATIVE ABUNDANCE OF SOME BENEFICIAL INSECTS ON COTTON PLANTS TREATED BY CERTAIN INSECTICIDES

(with 4 Tables)

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INTRODUCTION

A considerable controversy between entomologists concerning the successful method of controlling cotton insects, has long been existing. Some workers are in favour of biological control. Others, however, prefer the chemical control irrespective of how destructive chemicals may be to beneficial insects.

In fact both control measures, namely chemical and biological, are indispensable. However, chemicals destroy predators and parasites along with the harmful insects. Toxicologists, therefore, choose specific (selective) insecticides that would destroy the harmful pests and, in the meantime, do not affect the useful insects considerably. Preference between chemicals controlling cotton pests should, therefore, be made on basis of their action on useful insects.

The present study was thus carried out to clear up the effect of some of the commonly used insecticides on the population level of some predators frequenting cotton plants. As the biological observations may not be conclusive in a definite way, critical statistical analysis in the system demonstrated in this paper should be followed in order to reach any valuable conclusions.

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MATERIALS, METHODS AND TECHNIQUES

Four of the insect predators commonly present on cotton during its growth season were chosen for the present investigation. These are:

(1) The 11-spotted lady bird beetle, *Coccinella undecimpunctata* L., present on cotton throughout the growth season (March to October). Both adults and grubs prey upon aphids, mealy bugs and eggs as well as larvae of the cotton leafworm, *Prodenia litura* F.

(2) The rove beetle, *Paederus alfieri* Koch (Staphilinidae), common in cotton fields particularly during June and July. The effectiveness of this beetle in the destruction of cotton leafworm egg masses was recorded by several authors.

(3) The Anthocorid bug, *Orius* (= *Triphleps*) sp., an active predator which subsists on *Prodenia* eggs.

(4) The *Scymnus* beetles, both *syriacus* Mars. and *interruptus* Goeze, common on cotton between April and September are active predators on mealybugs, aphids and young larvae of *Prodenia*.

In addition to these predacious insects, the arachnid *Chirocanthium isiacum* Cambr., which is a medium sized spider known for its active destruction to *Prodenia* eggs and larvae, was studied here as well.

The chemicals used during the present study are some of the comparatively effective insecticides against many harmful cotton insects, particularly the cotton leafworm and the cotton bollworms. These materials are Toxaphene 2%, Parathion 0.1%, Voratox (Ciba-570) 0.1%, Voratox 0.2%, Systox 0.5%, Cotton dust 3/10/40.

Each of these chemicals was used in three applications, as indicated in Table 1, on ten cotton plots distributed at random within the experimental field, including a total of 70 small plots of about 1/2 kirat each (about 68 sq. meters each). Of these small plots sixty were used for the various treatments (10 treated by each insecticide) and ten were left untreated and used as a check. The experiment was carried out on the Faculty of Agriculture Farm at El-Marg, some 10 miles North of Cairo during the summer of 1957.

Liquid insecticides were sprayed by a small power sprayer (about 100 lbs/sq. inch) while the dust was applied by ordinary knap-sac dusters.

Predators population studies were made throughout the season after the application of the insecticides; the dates of applications are indicated in Table I. Predator sampling was carried out by both sweeping and counting of insects on individual plants representatives of each plot. Sampling was carried out during the early hours of the morning (7 to 9 a.m.) when predators are supposed to be at their optimum activity.

EXPERIMENTAL RESULTS

The data obtained during the present study are summarized in Table I and are analysed statistically in Table II.

TABLE I

Counts of predators in different treatments.

Chemicals	Number of predators per ten plants representing each treatment												Total	Mean
	After 1st treat- ment (during July)				After 2nd treatment (July-August)					After 3rd. treatment Aug-Sept.				
	1	4	12	24	26	2	11	21	27	29	6			
Toxaphene	56	84	47	37	26	27	18	16	10	17	1	339	30.8	
Parathion	76	42	40	85	15	38	11	20	4	5	13	349	31.7	
Voratox 0.1%	42	58	62	70	9	21	18	13	9	6	2	310	28.1	
Voratox 2	48	39	42	35	37	45	28	12	10	4	8	308	28.0	
Systox	70	71	41	42	36	44	24	11	17	1	2	359	32.6	
Cotton dust	57	59	53	32	24	30	15	18	11	3	7	209	28.0	
Check	76	25	84	33	39	34	17	29	6	12	8	363	33.0	
Total	425	378	369	334	186	239	131	119	67	48	41	2337		

From the Table I it appears that the chemical treatments have caused a variable reduction in the population level. Some of this reduction may be due to the seasonal natural reduction and not necessarily entirely due to the chemical treatments themselves. The effect of the various environmental factors on the population of the different predators has to be analysed critically before any definite conclusions along this line can be drawn.

A detailed statistical approach can be applied in the present and similar experiments. In this system outlined below the following points are to be considered:

- (1) The number of observations given in the table would be = n
- (2) The total (2337) = T
- (3) Each observation in the Table = $\times_1, \times_2, \times_3, \times_{77}$.
- (4) The vertical totals for 11 dates = D_1, D_2, D_{11} .
- (5) The number of dates (11) = ND

(6) The horizontal totals for the seven treatments or materials including the check = M_1, M_2, M_7 .

(7) The number of materials (7) = NM.

The analysis of variance would be carried out following the scheme outlined in Table II.

TABLE II

Scheme for the method of analysis of variance between the effect of different insecticides on the predators.

Variance source	D.F.	S.S.	M.S.
Correction factor	1	$\frac{T^2}{n} = A$	
Materials corrected	$(NM-1) = K_2$	$\frac{(M_1)^2 + (M_2)^2 + \dots + (M_7)^2}{ND} - A = D$	$\frac{D}{K_2}$
Dates corrected	$(ND-1) = K_1$	$\frac{(D_1)^2 + (D_2)^2 + \dots + (D_{11})^2}{NM} - A = C$	$\frac{C}{K_1}$
Residue (Error)	$(n-1) - (K_1 + K_2) = K_3$	$B - (C + D) = E$	$\frac{E}{K_3}$
Total corrected	$(n-1)$	$(\times_1)^2 + (\times_2)^2 + \dots + (\times_{77})^2 - A = B$	

This analysis procedure permits testing the following points:

(1) The hypothesis that all materials have equal means which could be obtained by dividing $\frac{D}{K_2}$ over $\frac{E}{K_3}$ which, of course, could also mean multiplying $\frac{D}{K_2} \times \frac{K_3}{E}$; and comparing the result with the F value in the F tables at 5% level with K_2 and K_3 degrees of freedom.

(2) The hypothesis that all dates have equal means $\frac{C}{K_1}$ over $\frac{E}{K_3}$; that is $\frac{C}{K_1} \times \frac{K_3}{E} = F$ with K_1 and K_3 degrees of freedom.

According to this system of analysis the following analysis of variance could be presented in case of the data at hand as recorded in Table I.

Although it is shown from Table I that all the materials tested had a reducing effect upon the mean numbers of predators as compared with the control (check) mean, yet the above analysis of variance indicates a nonsignificant difference between the treatments as a whole. This non-significance between materials may be attributed to the smallness of the plots and the overlapping of chemicals due to that the treated plots were close to each other. On the other hand the statistical analysis carried out here indicates a significant difference between dates which is

TABLE III

Analysis of variance of the effect of chemicals on predators.

Variance source	D.F.	S.S.	M.S.	F
Correction factor	1	70929.40	—	—
Materials corrected	6	326.70	54.4	insignificant
Dates corrected	10	29404.70	2940.5	0.05
Error (residual)	60	70527.20	1175.4	—
Total corrected	76	100258.60	—	—

biologically immaterial as the population of predators was naturally dropping down by the end of the summer season.

In spite of the result the value of L.S.D. (least significant difference) between the chemicals effect could be further calculated according to the formula:

$$\text{L.S.D. at 5\% level} = \sqrt{2} \cdot t_{k_3} \text{ at } 0.05 \cdot \frac{\sqrt{\frac{E}{K_3}}}{\sqrt{ND}} \text{ which equals 8. Table IV}$$

is obtained by arranging the means of chemicals according to magnitude.

TABLE IV

Chemicals	Mean
Voratox (2)	38.0
Cotton dust	28.0
Voratox (1)	28.1
Toxaphene	30.8
Parathion	31.7
Systox	32.6
Check	33.0

Since no difference between the means of any two materials exceeded the L.S.D. (8), no grouping is attempted.

DISCUSSION AND CONCLUSIONS

The insecticides used at present vary as to their effectiveness on the predators studied. Preference between chemicals applied for the control of cotton insects should be made on basis of the variations in their action on such useful insects. The less destructive an insecticide on the predators is, the more it is preferable for

this purpose assuming, of course, it is satisfactorily effective in controlling the cotton pests.

In order to be in a position to forecast any conclusions safely, more studies on the effect of these and other chemicals on the whole list of predators and parasites common on cotton throughout the season should be carried out. Predators and parasites of all cotton insects should be taken into the picture if definite valuable results are sought, a project planned for future investigation.

SUMMARY

A comparative study on the effect of some of the insecticides, commonly used for the control of cotton insects; on the population level of some predators was carried out. Analysis of the data perceived showed that the various chemicals do not significantly differ in their action on the predators. Biologically speaking, however, Systox and Parathion may be regarded as the least destructive to the useful insects taken into consideration here. Such materials may be preferred for the control of cotton insects provided, of course, that in addition to their mild action on predators they prove effective in the control of harmful pests. Toxaphene, Cotton dust and Voratox seem to be more destructive to predators than the two former materials.

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STUDIES ON DESERT INSECTS IN EGYPT

IV. REACTIONS OF *ADESMIA BICARINATA* KLUG TO SOME ENVIRONMENTAL FACTORS

[*Coleoptera: Tenebrionidae*]

(with 1 Text-Figure and 6 Tables)

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I. INTRODUCTION

Studies on the behaviour of desert insects have received little attention by previous workers. Valuable contributions, however, have been made by KENNEDY on *Locusta migratoria* (1937) and *Schistocerca gregaria* (1939). More recently, AZIZ (1957) studied the reactions of the latter species to physical factors with reference to relative humidity.

The present paper deals with the reactions of the Tenebrionid beetle *Adesmia bicarinata* to humidity, temperature and smell. It is hoped that the results obtained will lead to a better understanding of the life of this desert insect under such extremely adverse conditions as those prevailing in its normal environment. In a previous paper published by the present authors (HAFEZ and MAKKY, 1959 a), the bionomics of the same species and its adaptation to desert life were given and discussed.

II. HUMIDITY REACTIONS

1. Methods

The humidity behaviour of adult *Adesmia bicarinata* Klug was investigated in an apparatus substantially similar to that used and described by GUNN and KENNEDY (1936). The apparatus "the alternative chamber" consisted of a round glass basin 23 cm. in diameter and 6.5 cm. deep. The lower part of the basin was divided into two equal halves by a glass partition 0.5 cm. high fixed vertically to the bottom. Each half was provided with 12 small petri dishes 3.7 cm. wide and 2.2 cm. deep. These petri dishes contained the proper acid solution required to control the desired relative humidity in the above chamber. The circular arena was formed by the upper part of the basin on the top of the petri dishes. It was about 2.5 cm. high, while its floor was a round piece of perforated zinc covered by bolting silk (voile) exactly fitting the side walls of the jar and placed on the top of the petri dishes. The arena was covered with tightly fitting glass cover, which has a central circular hole for introducing the beetles; this hole was covered by a square piece of glass. To minimize the area of contact between the two halves of the arena, a thick glass rod was fixed along the middle of the inside of the lid so that it lay exactly opposite to the glass partition fixed at the bottom when the lid was in place. Care was taken to leave enough space in the arena above the floor to allow free and easy movement of the beetles in the chamber. Humidities in the arena were controlled with sulphuric acid water mixtures, prepared according to WILSON (1921), BUXTON and MELLANBY (1934), and SOLOMON (1951). The humidities were checked before each set of experiments by small hair hygrometers placed in the two halves of the arena.

The whole apparatus was shielded from direct light by a piece of grey paper that served also to distribute on it an evenly dim light.

All the humidity reactions were conducted under laboratory temperature conditions which ranged between 23-25°C. When humidity equilibrium in the apparatus was established, about ten beetles of the same sex and nearly of the same age were introduced through the central hole which was then quickly closed. The number of beetles moving to each half of the arena was recorded every 15 minutes, for two and a half hours. This gave a record of 100 positions for each experiment. Beetles that settled in the middle zone of the arena were not considered. After every 15 minutes the apparatus was rotated 180° in order to eliminate any possible bias of the insects to one particular side of the arena. Also the insects which normally tended to settle in one half of the arena, were activated by means of a small piece of wire.

The intensity of reaction was expressed by the excess percentage ratio $\frac{100 (D-W)}{(D+W)}$ (GUNN and GOSWAY, 1938) where D represents the total number of positions recorded in the drier half of the arena and W the number recorded in the wetter half.

Beetles kept under laboratory conditions gave no sharp response towards the various relative humidities offered in the alternative chamber, particularly towards low humidities. Therefore, all the experimented beetles were chosen from three stocks kept for 12-24 hours at the controlled humidities 10% R.H. (low humidity), 50% R.H. (medium humidity) and 90% R.H. (high humidity).

2. Experiments and results

Reactions of beetles pre-conditioned at 10% R.H.

Beetles desiccated at 10% R.H., in three sets of tests, were first offered the choice between two relative humidities in the alternative chamber in which one side differed from the other by 10% R.H. along the whole relative humidity scale. Thus the combinations provided were: 10 or 20%, 20 or 30%, 30 or 40%, 40 or 50%, 50 or 60%, 60 or 70%, 70 or 80%, 80 or 90%, 90 or 100%.

In all these combinations most beetles showed a strong preference to the drier side of the arena where they mostly aggregated. However, the intensity of reaction of these beetles differed in the different combinations. The highest intensity was observed at the high humidity combinations i.e. 90 or 100% R.H. (61%), 80 or 90% R.H. (58%) and 70 or 80% R.H. (55%). This intensity gradually decreased as we moved downwards along the humidity scale. Thus at 40 or 50% and 30 or 40% R.H. the intensity of reaction was 32.5 and 33%, respectively. At still lower humidity combinations, e.g. 10 or 20, the beetles still preferred the drier side with a higher reaction intensity of 50.0% (Table I).

TABLE I

*Intensity of reaction of desiccated Adesmia bicarinata
to various humidity combinations (Temp. 23-25°C).*

Humidity in dry side (D)	Humidity in wet side (W)	Percentage of intensity of reaction
90	100	61
80	90	58
70	80	55
60	70	44.5
50	60	43
40	50	32.5
30	40	33
20	30	40
15	25	48
10	20	50

In a second set of tests a series of relative humidity combinations were provided for the beetles in the alternative chamber. In all these combinations one

side of the chamber remained with a fixed relative humidity i.e. 20% R.H. while the other side changed gradually by about 10% R.H. higher, each time. The following pairs of relative humidity combinations were thus offered: 20 or 30%, 20 or 45%, 20 or 50%, 20 or 60%, 20 or 70% and 20 or 80% R.H.

The response of the beetles in this set was again a marked preference to the dry side of the arena. The intensity of reaction was highest (71.5%) at the 20 or 80% R.H. combination where the difference between the two alternatives in the chamber was greatest (60%) (Table II). This intensity of reaction, however, became considerably lower as the difference between the two relative humidities offered decreased (Table II). The lower intensity was thus obtained at 20-30% R.H. (40.0%).

TABLE II

Reaction intensity of desiccated Adesmia.

R.H. in dry side	R.H. in wet side	Percentage of reaction intensity
20	80	71.5
20	70	63
20	60	59
20	50	48
20	45	45
20	30	40

In the third series of tests the desiccated beetles were offered various alternatives in which the relative humidity of one side of the arena was fixed at 30%, 40%, 50%, or 60%, while the other side varied along the higher humidity range.

With all the alternatives offered the reaction intensity again varied according to the humidity difference between the two sides of the arena the greater the difference the higher the intensity (Tables II and III).

The results of the three sets of experiments indicate that *A. bicarinata* pre-conditioned at 10% R.H. showed a marked dry reaction. They mostly aggregated in the dry side of the arena and avoided the moist side. The intensity of reaction differed according to the humidity range offered, the higher the range the greater was the intensity, thus with the same humidity difference, e.g. 90 or 100, 60 or 70, and 40 or 50% R.H. the intensity of reaction was 61.0, 44.5 and 32.5%, respectively (Table I). This increased appreciation of humidity at the upper range was also observed in other insects and related arthropods, e.g. *Culex fatigans* (THOMSON, 1938), *Tenebrio molitor* (PIELOU and GUNN, 1940), *Pediculus humanus corporis* (WIGGLESWORTH, 1941), *Ixodes ricinus* (LEES, 1948) *Tribolium castaneum* (ROTH and WILLIS, 1950) and *Drosophila melanogaster* (PERTTUNEN and SALMI, 1956) which all avoid

moist air and aggregate in dry air. The same phenomenon was reported from *Musca domestica* larva (HAFEZ, 1950) and *Musca sorbens* larva (HAFEZ and ATTIA, 1958) which both avoid dry air.

TABLE III

Reaction intensity of desiccated Adesmia

R.H. in dry side	R.H. in wet side	Percentage of reaction intensity
30	90	73.5
30	80	64.5
30	50	45
40	90	69
40	80	62
40	75	60
40	60	48
40	50	32.5
50	90	64
50	70	57
50	60	45
60	95	55.5
60	70	44.5

The intensity of dry reaction also, as shown by the last sets of experiments, increased as the difference between the two humidities in the chamber became greater and considerably decreased as the difference became smaller; thus at 30 or 90 and 30 or 50% R.H. the intensity of reaction was 73.5 and 45.0% respectively.

Reaction of beetles pre-conditioned at 50% R.H.

These beetles were offered four pairs of alternatives in the arena. These were 25 or 50, 50 or 90, 70 or 90% R.H. and 90 or 100% R.H. (Table IV). In all the various combinations most of the beetles invariably moved to the dry side and avoided the wetter side of the arena even if it was exactly the same as that humidity at which they were pre-conditioned. The intensity of their dry reaction, however, differed markedly. The strongest reaction was demonstrated in the combination 50 or 90% R.H. (about 60.0%) this was followed by a lower intensity at 25 or 50% R.H. (48.0%) and a weak reaction at both 70 or 90% R.H. (30.0%), and 90 or 100% R.H. (36.0%). In these (70 or 90 and 90 or 100% R.H. combinations) where high humidity prevails in the arena the majority of beetles were indifferent to either side of the arena always wandering about or resting in.

From these results, it is evident that reaction intensity of beetles pre-conditioned at 50% R.H. depends mainly on the humidity difference offered and not on the humidity range.

TABLE IV

Humidity reactions of beetles pre-conditioned at 50% R.H.

R.H. in dry side	R.H. in wet side	Percentage of reaction intensity
25	50	48
50	90	59.5
70	90	30
90	100	36

Humidity reactions of beetles pre-conditioned at 90% R.H.

Beetles kept at 90% R.H. for 12-24 hours previous to the test (wet beetles) showed much sluggishness in their movements that it was difficult to get a clear response.

Table V gives the paired relative humidities offered to these beetles and the intensity of reaction.

TABLE V

Reactions of beetles pre-conditioned at 90% R.H. ()*

R.H. in dry side	R.H. in wet side	Percentage of reaction intensity
25	50	0
50	90	-37.5
70	90	0
90	100	8.5

* A zero intensity means either no reaction or equal distribution of beetles in the two sides of the arena. — A minus sign indicates a reverse reaction.

When these wet beetles were offered 90% R.H. in one side of the arena and 100% R.H. in the other side, they moved to the drier side, i.e. 90% R.H. but the intensity of these dry reactions was only 8.5%. When these wet beetles were given a combination of 25 or 50% R.H. or 70 or 90% R.H. no reaction was obtained. But when offered a combination of 50 or 90% R.H., the beetles gave a relatively marked avoidance to the lower humidity side preferring the wet 90% R.H. side with an intensity of wet reaction -37.5%.

The "no reaction" or "zero reaction" given by the beetles in the 25 or 50% R.H. and 70 or 90% R.H. combinations and the weak reaction at 90 or 100% relative humidity may be due either to the sluggishness of the wet beetles, so that most of them remained in the middle zone of the chamber, or to an indifference to either humidities offered in the alternative chamber.

Comparing the three types of beetles pre-conditioned at the three various humidities, the above results show that beetles which were pre-conditioned in a dry or a humid atmosphere showed a dry reaction and avoided moist air; at higher humidity, however, the reaction intensity diminished greatly. Thus, pre-conditioned beetles offered 90 and 100% R.H. as alternatives and pre-conditioned at 10, 50 and 90% R.H. showed reaction intensities of 61, 36 and 8.5%, respectively (Tables I, IV, and V). This probably indicates that the higher the pre-conditioning humidities, the lower is the ability of the insects to discriminate humidity differences.

In nature, however, where these beetles live in an extremely arid habitat, it was noticed that there was always present under the elytra, i.e. in the sub-elytral space a certain amount of moisture in the form of some drops of water. This might explain the extremely varied behaviour of the beetles, directly taken from the field, towards various humidity conditions. The dependence of *Adesmia bicarinata* on *Anabasis setifera* (a succulent desert plant) as food, may also provide the beetles with certain amount of water which might have a bearing on restoring their normal water balance. Furthermore the preference of the beetles to the low humidity range after desiccation may be correlated with a high resistance to the arid conditions of the desert and the maintenance of the normal water balance of the cell sap, a result expected from animals living in a dry atmosphere.

The migratory locust *Locusta migratoria migratorioides*, a typical desert insect, always oriented towards the dry side of the alternative chamber even if it was desiccated (KENNEDY, 1937). GUNN and COSWAY (1938) and THOMSON (1938) found that *Blatta orientalis* and *Culex fatigans* showed constant preference towards the low humidity side. The mealworm beetle *Tenebrio molitor* (PIELOU and PIELLOU and GUNN, 1940) displayed a marked dry reaction whatever the humidities offered. This latter insect in nature, is found in a dry environment with little moisture content (PIELOU, 1940). Similarly WIGGLESWORTH (1941), BENTLEY (1944) and LEES (1948) mentioned that *Pediculus humanus corporis*, *Ptinus tectus* and *Ixodes ricinus*, respectively, favoured the dry side of the arena. DAKSHINAMURTY (1948), on the other hand, remarked that the dry and wet flies of *Musca domestica* orientated always towards the dry side of the apparatus but the intensity of the dry reaction was not the same in both cases. The larva of *Dermestes ater* underwent a dry reaction after being pre-conditioned on a wet filter paper (ROTH and WILLIS, 1951). However, *Tribolium confusum*, *T. castaneum*, *T. destructor* and *Sitophilus granarius* if starved and desiccated showed a strong wet reaction (ROTH and WILLIS, 1950 and 1951). *Tribolium castaneum* showed a dry reaction if preconditioned on wet air or when its water balance was normal (ROTH and WILLIS, 1950). PERTTUNEN (1951), on the other hand, found that the dry initial reaction is displayed by the carabid beetles, *Harpalus serripes*, *Harpalus punctatulus* and *Odacantha melanura* which was soon reversed if these beetles were previously desiccated. The latter author (1955), also demonstrated that the initial dry reaction of the carpenter ant *Camponotus herculeanus*

was changed into indifference, then reversed to a moist one when the insects were tested two days after their capture and preconditioned in wet air.

3. Humidity receptors

The perception of air humidity by special sensory organs, the humidity receptors, located on the antennae of beetles have been suggested by various authors. PIELOU (1940) found that both the pit-peg organs and the peg organs on the antennae of *Tenebrio molitor* are the organs receiving humidity stimuli. Also in *Ptinus tectus*, the antennae were proved to be the seat of humidity receptors (BENTLEY, 1944). ROTH and WILLIS (1951, a and b) similarly found that the humidity reactions of three species of *Tribolium* can be correlated with the distribution of basiconic sensillae (peg organs) on the antennae. The same authors identified various types of sensillae as probable hygroreceptors on the antennal club segments of six other beetles. PERTTUNEN (1951) found that the amputation of the antennae in some carabid beetles nearly abolished the humidity reaction. Also AZIZ (1957) concluded that the antennae of *Schistocerca gregaria* Forsk. hoppers are the seat of hygroreceptor organs.

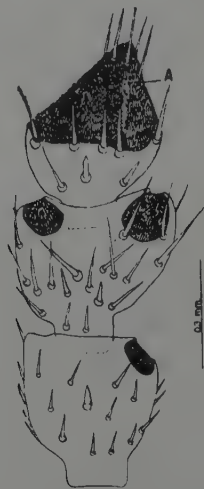


FIG. 1: The three apical antennal segments of *Adesmia bicarinata* Klug (A, peg organs).

In other insects, however, it was found that hygroreceptors are situated on various parts of the body (WIGGLESWORTH, 1941; LEES, 1943; HOGBEN, 1946; HAFEZ, 1950 and 1953).

The three apical antennal segments of *A. bicarinata* carry special sensory sensillae, the peg organs, located on well defined membranous areas (Fig. 1, A.).

These peg organs were found to be the hygroreceptive organs, indicated by the following experiments.

The methods employed consisted of the successive amputation of the antennal segments. The treated beetles were then exposed to two different relative humidities one favourable and the other unfavourable and the intensity of reaction was recorded.

The amputation method was previously followed by PIELOU (1940) to locate the hygroreceptors on the antennae of *Tenebrio molitor*; by WIGGLESWORTH in the body louse *Pediculus*; by HAFEZ (1950) in *Musca domestica* larva; by ROTH and WILLIS (1951) in adult *Tribolium* and by PERTTUNEN (1951) in some Carabid beetles.

In *A. bicarinata*, the antennal segments were amputated one by one with the help of a razor blade under the binocular microscope. This method seemed to have no ill effect on the beetles which soon recovered.

Three groups of treated beetles were desiccated at 10% R.H. In the first group only the apical segment of both antennae were amputated. In the second group two segments were cut off while in the third group the three apical segments were removed.

Table VI shows the intensity of reaction of desiccated beetles, with antennal segments successively amputated as compared with normal beetles, when offered the alternative relative humidities 30 or 90%.

TABLE VI

Effect of various amputations of the apical segments of the antennae on the humidity reaction of Adesmia.

R.H. in dry side	R.H. in wet side	Number of antennal segments	$\frac{D-W}{D+W} \times 100$ reaction intensity
30	90	11	73.5
30	90	10	45.0
30	90	9	31.0
30	90	8	0
30	90	7	0

Normal beetles, with complete antennae, gave an intense dry reaction 73.5% in this relative humidity combination. However, when the apical segments of both antennae were removed the intensity of this dry reaction became lower (45%) by about 28.5%. Beetles with the two apical segments amputated still showed avoidance of the wet side of the arena, but the intensity of this dry reaction was considerably reduced to about 31% (Table VI). However, beetles became completely indifferent

to both relative humidities, giving no reaction, when the three apical segments of both antennae were completely amputated.

Thus these results show that the possible humidity receptors of *A. bicarinata* are located on the three apical antennal segments and that the successive removal of any of them considerably reduced the intensity of the humidity response. Removal of the three apical segments, however, completely eliminated the humidity reaction and the beetles became indifferent to variations in relative humidity.

III. TEMPERATURE REACTIONS

1. Methods

The temperature reactions of *A. bicarinata* were investigated in an apparatus similar to that used by WIGGLESWORTH (1941). It is composed of two copper tanks $20 \times 20 \times 9$ cm. held together by a metal strip and separated by a sheet of asbestos 2 mm. thick. Hot or cold water circulated in the tanks or more conveniently, water in the tanks was heated to the desired temperature by means of micro-burners under the tanks.

Behaviour of *A. bicarinata* was observed in a circular arena placed over the water tanks and thus arranged to offer the experimental individuals two different intensities of the factor at a time. The perforated zinc arena floor was covered by bolting silk (voile). The arena a glass ring 5 cm. in height and 19 cm. in diameter, was covered by a tightly fitting glass cover provided with a central hole for introducing the beetles; this hole was covered by a square piece of glass. Before each experiment the temperature of the arena was checked by a thermocouple.

Ten mature adults of the same sex were used in each experiment. Ten records of the position of the beetles in the arena were obtained every 5 minutes and the number of beetles resting in the middle zone was discarded.

Relative humidity of the arena was kept constant at 50% R.H. by filter papers placed 2 mm. below the perforated zinc floor soaked in saturated salt solution giving this humidity and the whole apparatus was shielded from direct light.

According to the following formula: the intensity of reaction = $\frac{100 (N_2 - N_1)}{N_2 + N_1}$ where N_2 is the number of position records from the warmer side of the arena and N_1 is the number from the cooler side.

2. Experiments and results

Uniform temperature

The effect of uniform temperature on the behaviour of the beetles was first studied. In this case the arena was rested on one tank. The temperatures tested were 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50°C.

The beetles in an arena with 5, 10 or 15°C. were very sluggish, mostly inactive and moved with difficulty and had a rather chilled appearance. At 20°C. the beetles showed slight activity while at temperatures above 20°C., the activity and the movements of the beetles became a function of temperature and increased as the temperature became higher up to 45°C. Above 45°C., however, i.e. at 50°C. the beetles were greatly agitated, and erratic, and tried to climb on the glass wall, presumably to escape the apparently unfavourable temperature of the arena.

Alternative temperatures

The behaviour of the beetles was first tested in a number of preliminary experiments in which the insects were offered the choice of 20 or 35°C. Complete avoidance of the cooler temperature was observed and the beetles always aggregated in the warmer side of the arena. Within that range the reaction was the same even when much smaller temperature differences were offered (e.g. at 25 or 29; 29 or 31; 31 or 32.5°C.). When this result was obtained, the response to other differences on the temperature scale (10-45°C.) was then studied in order to find the zone of indifference to temperature and also the threshold high and low temperatures necessary to elicit a response. For this purpose, two sets of experiments were conducted; in one set the temperature on one side of the alternative chamber was kept at 35°C. and progressively raised on the other side. In the other set the temperature was kept at 20°C. on one side and progressively lowered on the other.

The results of these experiments showed a distinct zone of indifference to temperature differences extending from 35 to 45°C. and another zone from 20 to 10°C. In both cases the beetles showed no preference to either side of the alternative chamber even when the difference offered was as great as 10°C. In the former zone, however, the beetles were active and in the latter rather sluggish.

Above 45°C. the beetles were sensitive to very small temperature differences always avoiding the higher temperatures, the avoiding reaction varying in intensity according to the difference offered. Thus at 45 or 45.5, 45 or 46; 45 or 48°C. and 45 or 48.5°C. the reaction intensities were 20.5, 60, 90 and 100, respectively. Below 10°C. on the other hand, the cooler side of the arena was avoided but the beetles seemed much less sensitive. Thus the intensity of reaction to the same temperature difference (3°C.) was 90% at 45 or 48°C. (with the avoidance of higher temperature) and 20% at 7 or 10°C. (with slight avoidance of the lower temperature).

Pre-conditioning

The possible effect of temperatures, to which the beetles had been previously exposed, on behaviour was tested on the following way. Four groups of beetles were preconditioned at 15, 20, 25 and 29°C. respectively. In all cases the preconditioning seemed to have no influence on the behaviour of the beetles; preconditioned beetles consistently avoided the cooler side of the arena and always aggregated on the warmer side. In no case the intensity of reaction was less than 100%.

3. Temperature receptors

In locating the temperature receptors, beetles with amputated antennae or maxillary palps, or tarsi each at a time, were offered the temperature alternatives 25 or 29°C. in the arena. The method was similar to that carried out in locating the humidity receptors.

Antennaless beetles readily moved to the warmer side of the arena, i.e. 29°C. with a reaction intensity of 100%.

Beetles with amputated maxillary palps or tarsi also avoided the cooler side of the arena, i.e. 25°C. and preferred the warmer side 29°C. (intensity of reaction in both cases 100%).

This indicates that the antennae, maxillary palps, and the tarsi contain no special temperature receptors.

Thus it could be assumed that environmental temperature may be sensed through the general body surface of *A. bicarinata*. The beetles possess a thick covering of sensory bristles distributed on the whole body surface which are particularly dense on the ventral surface.

In many insects, however, various investigators studying the temperature reactions were unable to identify special temperature receptors. WIGGLESWORTH and GILLET (1934) considered that the numerous thick-walled trichoid sensillae of *Rhodnius* are probable temperature receptors; WIGGLESWORTH (1941) suggested that the peg organs of the fifth antennal segment of *Pediculus* have the same function although he concluded that temperature is equally sensed elsewhere on the body. LEES (1948) and HAFEZ (1950) suggested that the temperature of the environment are sensed in the tick *Ixodes ricinus* and the larva of *Musca domestica* respectively through the general body surface.

IV. SMELL REACTIONS

1. Experiments and results

The behaviour of *Adesmia bicarinata* towards various odours of acetic acid, ammonia, formaldehyde, the desert plant *Artemesia judaica*, human excrement and camel dropping was studied in the alternative chamber.

In these experiments the arena was arranged as in the case of temperature reactions and the material was placed 2 mm. below one half of the zinc floor while the other half remained neutral, i.e. free from any odour.

Acetic acid, ammonia and formaldehyde were used at a concentration of 0.75%. Filterates of the boiled dry *Artemesia judaica*, diluted human excrement and diluted camel dung were tested each at a time. Temperature and humidity were kept constant at 30°C. and 75% R.H. Each experiment lasted for about an hour and the intensity of reaction was expressed as in the case of the humidity and temperature reactions.

When one side of the arena was scented with acetic acid or ammonia and the other side left neutral, the beetles showed a weak avoidance of the acetic acid or ammonia scented side, with a reaction intensity of 23%. Formaldehyde, however, was strongly avoided, the reaction intensity amounting to 40%.

When on the other hand, one half of the arena was scented with human excrement or camel dung and the other half was untreated the beetles showed indifference to both halves indicating no response to faecal smell. Similarly in the arena with *Artemesia judaica* the beetles were equally dispersed in the two sides of the arena and showed no preference to either side.

The above results show that *Adesmia bicarinata* was sensitive to the smell of various chemicals used, i.e. acetic acid, ammonia or formaldehyde. On the other hand, it showed no response towards human excrement, camel dung or *Artemesia judaica* which are encountered in its natural habitat.

2. Smell receptors

To locate the possible chemoreceptors, the organs carrying sensory sensillae such as the antennae, tarsi and maxillary palpi were successively amputated. An arena with one side scented with formaldehyde (0.75 solution) and the other side neutral was offered to the treated beetles.

Antennaless beetles were sensitive to the odours in the formaldehyde side which it strongly avoided. The same reaction was also manifested by beetles with amputated tarsi. It seems therefore that neither the antenna nor the tarsi contain chemoreceptive sensillae. On the other hand, beetles with amputated maxillary palpi when offered the above alternatives showed no avoiding reaction towards the scented side and were equally dispersed in the alternative chamber indicating that the maxillary palps possibly contain the organs sensitive to smell. It may be suggested that the peg organs on the apical segment of the maxillary palps are the chemoreceptors.

FRINGS and FRINGS (1949) showed that the sensillae on the tips of both the maxillary and labial palps of Coleoptera are contact chemoreceptors. In *Tenebrio molitor*, PIELOU (1940) found out that maxillary palps are sensitive to chemical substances, while in *Pediculus humanus corporis* WIGGLESWORTH (1941) found that the peg-organs on the antennae are the chemoreceptive organs. LEES (1948), however, proved that HALLER's organs on the tarsi of *Ixodes ricinus* are chemoreceptors.

V. THE REACTIONS OF *ADESMIA* AND THE NORMAL ENVIRONMENT

The humidity reactions of *Adesmia* may have some bearing on its life in the normal environment. It showed no definite preference to any humidity offered in the alternative chamber when it was brought directly from the field and tested. This irregular behaviour may be related to the humidity conditions prevailing in

the normal habitat of the insect which comprise a wide range of daily fluctuations almost approaching saturation just before sunrise and falling to about 20% R.H. at mid-day. Only when preconditioned, the beetles showed a clear and definite response almost always avoiding moisture and favouring dryness with variable intensities. The dry response was marked even when the beetles were desiccated at a very low humidity (e.g. 10% R.H.). Such behaviour may be correlated with the high power of resistance of the beetles to desiccation, which is one of the requirements of desert life. Among other insects, the migratory locust, *Locusta migratoria migratorioides* (KENNEDY, 1937), gave a similar reaction and it always preferred the dry side of the apparatus, even when it was previously kept under low humidity (dry) before the experiment.

The behaviour of the insects towards humidity was explained by many authors to be related to the state of water balance in the cell sap of the animal under investigation. Thus, ROTH and WILLIS (1951) found that *Dermestes ater* larva underwent a dry reaction after being pre-conditioned on a wet filter paper. They also remarked that the starved and desiccated *Tribolium confusum*, *Tribolium castaneum* and *Sitophilus granarius* showed a strong wet reaction. Furthermore, PERTTUNEN (1951) found that the carabid beetles of dry habitat *Harpalus serripes*, *Harpalus punctatulus* and *Odacantha melanure* gave an initial dry reaction that was destroyed when they were previously desiccated. The same authors proved that the initial dry reaction of both *Harpalus serripes* which is a xerophilous species, and *Harpalus punctatulus* that is a less xerophilous one, was reversed to a wet reaction in the case of the former species after three days (indicating a high resistance to dryness), while in the case of the latter species, only after three hours (indicating a lower resistance to dryness) in the apparatus. The same conclusion was arrived at by LINDROTH (1948) about these two species. On the other hand, the hygrophilous carabid species, *Dyschirius arenosus*, *Elaphrus cupreus*, *Blethisa multipunctata*, *Oodes gracilis* and *Agonum versutum* showed a rapid moist response (PERTTUNEN, 1951).

The beetle is dorsally convex, and thus the incident sun rays, when vertical at mid-day, fall obliquely on the insect abdomen and thus the body temperature may not rise so high.

The general behaviour of the beetles is largely controlled by temperature. They are inactive below 15 or 20°C., but they are gradually activated as the temperature rise up to 50°C. A range of preferred temperature or thermo-preferendum, however, occurs between 35-45°C. which is not at all surprising as such range usually prevails in the normal environment of the insect. At temperatures higher than 45°C., the beetles became greatly disturbed, erratic and there seem as to be a rapidly increasing sensitivity to temperature difference displayed by the beetle as the temperature approaches 45°C. A half degree centigrade higher than 45°C. elicits a response with a slight avoidance of the higher temperature, the avoiding reaction becoming more intense and complete (100%) at 48°C. That is why in nature in hot days the insect is to be looked for in the shade under rocks and shrubs. This

avoidance of high temperature may also explain the complete disappearance (possibly through perishing) of *Adesmia* from the desert during the summer and early autumn.

In nature, however, the insect does not seem to show preference towards smelly objects in the desert. It is naturally distributed under all kinds of desert plants either scented (e.g. *Artemisia judaica*) or not (e.g. *Anabasis setifera*) and therefore it seems that the behaviour of the insect in the desert is governed by factors other than smell.

VI. SUMMARY

The reactions of *Adesmia bicarinata* to some environmental factors were studied in an alternative chamber in which the beetles were offered the choice of two different intensities of one factor at a time.

(1) Humidity reactions:

(a) Beetles kept under laboratory conditions gave no definite response towards the various relative humidities offered. Only when preconditioned, the beetles displayed their response.

(b) Beetles desiccated at 10% R.H. (dry beetles) showed a strong preference to the drier side of the arena, the intensity of the reaction being highest at the upper humidity scale (e.g. at 90 or 100%), and lowest at 30 or 40% and 40 or 50% R.H.

(c) When the humidity difference offered varied, the intensity of the dry reaction also varied. Thus at 30 or 90 and 30 or 50% R.H. the reaction intensity was 73.5 and 45% respectively.

(d) Beetles preconditioned at 50% R.H. again consistently avoided the moister side of the arena and aggregated on the drier side.

(e) Beetles preconditioned at 90% R.H. (wet) gave a wet response when they were offered to choose between 50 or 90% R.H. and no response at 25 or 50 and 70 or 90% R.H. At 90 or 100% R.H., however, the beetle showed a very weak dry reaction.

(f) The three apical antennal segments (carrying the peg organs) are the seat of the possible humidity receptors.

(2) Temperature reactions:

(a) The beetles in an arena of uniform temperature and with 5, 10, or 15°C. were inactive but at 20°C. or higher temperatures, the movements of the beetles became a function of temperature and increased as the temperature became higher up to 45°C., above which the beetles were greatly agitated.

(b) The insects avoid completely the cooler side when they are offered the choice of 20 or 25°C.

(c) Within the range 20-35, the reaction was the same (complete aggregation on the warm side), even when much smaller differences were offered e.g. 25 or 29, 29 or 31, or 32.5°C.

(d) Two zones of indifference to temperature gradient were observed in the temperature scale, one extending from 35 to 45°C. and the other from 20 to 10°C.

(e) Above 45°C. the reaction is reversed, the beetles always preferring the cooler side of the arena. They also display great sensitivity to small temperature differences, e.g. at 45 or 45.5°C.

(f) Pre-conditioning has no appreciable effect on the reactions of the beetles to temperatures.

(g) There are no special temperature receptors, the temperature stimuli are possibly received by the whole body surface.

(3) *Smell reactions:*

(a) The beetles could not detect the smell of both *Artemisia judaica*, a desert highly scented plant, and camel dung.

(b) They avoided the odours of formaldehyde, acetic acid and ammonia.

(c) The maxillary palp is the chemoreceptive organ.

The reactions of the beetle to temperature, humidity and smell and their bearing on its habits in its natural environment are also discussed.

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NEUE ORIBATIDEN AUS AEGYPTEN

[*Acarina*]

(mit 28 Abbildungen)

von Dr. EGON POPP,

aus der Evertibraten-Abteilung der Zoologischen Staatssammlung München.

Die Oribatiden, die in dieser Arbeit beschrieben werden, sammelte MOHSEN S. TADROS, Kairo, bei bodenzoologischen Untersuchungen in Aegypten. Der Sammler gibt folgende Angaben zu Fundort und -zeit: Giza (30° 2' n. Br.): Kulturlandstreifen am Westufer des Nils, 25 m ü. M.; mit *Triticum*, *Zea mays* und *Linum*. Sandiger Lehm Boden (chem. Analyse vgl.: EL-KIFL 1957). Standortmakroklima im Sammelmonat Dezember 1957:

Temperatur exp. in 2 m Höhe: Maximum 20,4°C., Minimum 7,2°C., Monatsmittel 14,7°C.

Relative Luftfeuchtigkeit in 2 m Höhe: Minimum 28%; Monatsmittel 78%. Sonnenscheindauer 219 Stunden (=69%). Niederschlag in Spuren.

Die Milben wurden mit TULLGREN-Apparaten erhalten, die jeweils mit einer 5 cm dicken Substratschicht beschickt waren. Die Proben entstammen einem Bodenprofil von 0-30 cm.

Oppia sticta, n. sp.

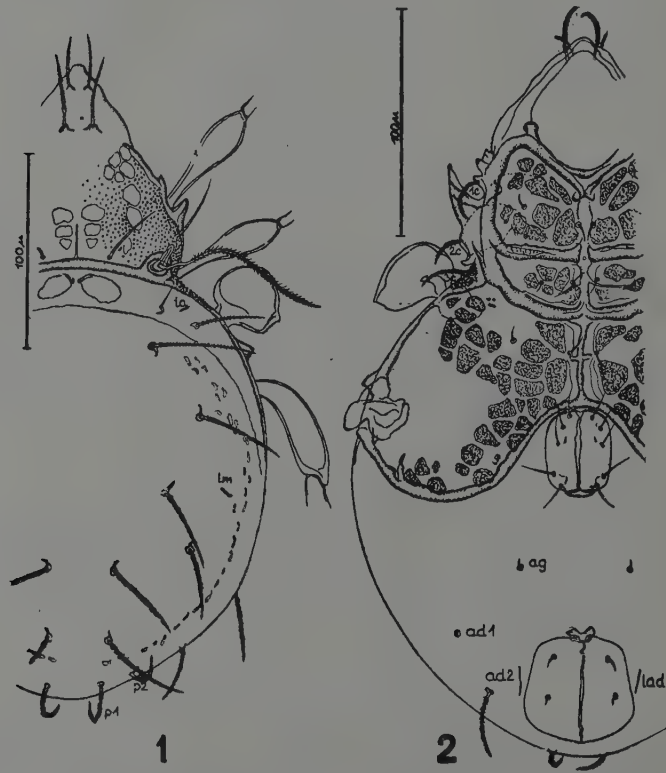
(Fam.: *Oppiidae*)

Habitus: Farbe (n. RIDGWAY 1913) "yellow ocker" (Pl. XV, Nr.17).

Körperlänge: 323µ; Körperbreite: 210µ. Ohne Lamellen. Propodosoma dorsal mit 6 medianen Flecken und einer Reihe randnaher Seitenflecken; ventral mit vielen Flecken auf den Epimeralfeldern (Abb. 1-5).

Propodosoma: Rostrumspitze propfenartig. Beborstelte Rostralhaare (Länge 24µ) um 13µ dorsad vom Rostrumrand nach hinten gerückt; wie die beborstelten Lamellarhaare (Länge 51µ) auf Höckern insertiert. Diese sind bei den Lamellarhaaren 37µ vom Rostrumvorderrand, 75µ von der Vorderkante der Rückenschildvorderleiste entfernt. Propodosoma dorsal im vorderen Bereich glatt, die Flanken

sind nach hinten zu von der Körpermitte aus immer stärker mit Poren und Papillen besetzt. Von der Rückenschildvorderleiste springt median ein schmaler, 10μ langer Grat vor. Zu seiten dieses Grates liegen auf der Geraden durch die Rostral- und Lamellarhaarhöcker je 3, rostral grösser werdende, gerundet rechteckige, bezw. dreieckige (hintere) Flecken. Die beborstelten Interlamellarhaare (Länge 40μ geschätzt !) sitzen knapp vor der Vorderleiste zwischen Grat und Bothridienmuschel.



Oppia sticta, n. sp.

ABB. 1: Dorsalansicht. — ABB. 2: Ventralansicht.

Zwischen Mittelflecken und Propodosomaseitenrand liegen Flecken in einer Reihe (3-4) und davor ein Herd (4-6). Die Vorderleiste des Rückenschilds umschliesst das Bothridium mit einem kräftigen Ringwall. Aus der Organöffnung ragt ein durchscheinender fingerförmiger Zipfel nach vorne. Der Sensillus (Länge 115μ

gestreckt !) ist S-förmig zur Seite geschweift, an keiner Stelle verdickt, endet in einer scharfen Spitze und ist stark und rundum befiedert.

Das ventrale Propodosoma ist durch kräftige Apodemalleisten gegliedert. Die Apodemata 1 ziehen schräg nach hinten, stossen sternal zusammen und biegen zu einem Hacken um. Das Mentotectum ist bis auf den medialen Bogen und die kräftigen Gelenkköpfe des Gnathosomas verdeckt. Die Apodemata 1 verbinden sich mit einem randnahen Bogen mit den breiten Apodemata 2, die medial bis auf den Sternumstreifen zusammentreten, und laufen, leicht nach hinten ausgebuchtet, in den Apodemata 3 aus, die sich als Sternum rostrad aufbiegen. Die eben beschriebenen Apodemata gleichen einem axial verzerzten Fensterrahmen. Ein Apodema zwischen 2 und 3 ("sejugal") entspringt am Sternum als schmaler, kurzer Grat, der in seinem Verlauf von den Epimeralflecken gestört wird. Die 4. Epimeralfelder drängen zu seiten des Genitalfelds bis zur Höhe des Hinterrandes der Genitflügel vor (vgl. : *Lebertia*), werden dort von einer breiten Leiste eingefasst und von einem kreuzförmigen Sternum geteilt. Alle Epimeralbereiche tragen grosse, symmetral verschieden geformte und in der Zahl unterschiedliche Chitinflecken, deren Felder rauh erscheinen (Milchsäure-Trypsinbehandlung). Die weitere Umgebung an der 4. Coxa ist fleckenfrei. Die Epimeralborsten sind glatt und dornartig gebogen (1-4 a-b) oder beborstelt, lang (1-3 c). Tectopedie I 2 stumpfe kleine Höcker, Tectopedie II gattungstypisch, Tectopedie III ein quer abstehender kleiner Hacken, Discidium dreieckig. Die Kerbe bei 3c ist auffallend weit ventrad chitinös verstärkt und mit Papillen besetzt.

Hysterosoma: Der ovale Rückenschild ist bis auf eine randnahe Reihe kleiner länglicher Muskellansatzperforationen glatt. Nur knapp hinter dem Vorderrand hängen median 2 elliptische Flecken an mediad zusammenstehenden Chitinspangen. Die beborstelten, langen Rückenborsten sind in der Lage gattungstypisch auf kommaförmigen Chitinsockeln insertiert; *p1* und *p2* sind ventrad umgebogen. Es sind senkrecht zum Rand stehende Pseudofissuren (*ia*, *im*) von 5-7 μ Länge vorhanden.

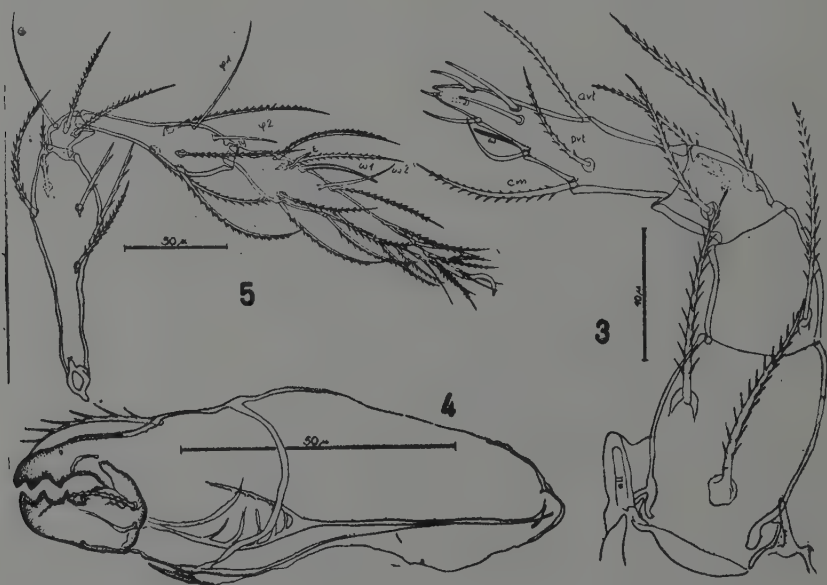
Das ventrale Hysterosoma ist glatt, das Genital- und Analfeld sind ohne zusätzliche verstärkende Umrahmung. Das Genitalfeld (Länge 38,5 μ Breite 31 μ) hat Flügel mit ineinandergreifender Zahnung und rostrader Ausbuchtung; jeder Flügel trägt 5 glatte Borsten. Das Borstenpaar *ag* ist dornförmig. Zu seiten des Analfelds (Länge 79 μ ; Breite 69 μ) liegen schmale Pseudofissuren (*iad*), die an einem Tier mitunter auf der einen Seite als geteilter Spalt auftreten. Die analfeldnahen Borsten sind dornförmig (*ad 1*) oder lang und beborstelt (*ad 2*). Von den Analflügeln, deren vorderes Gelenk kräftig ausgebildet ist, trägt jeder 2 Dornborsten.

Palpe (Abb. 3): Gedrungen. Borstenformel: 0-2-1-3-10. Alle Femur-, Genu- und Tibiaborsten, ferner die Culminal (*cm*), Para- und Antiventralborsten (*pvt*, *avt*) des Tarsus kräftig, mit grober Befiederung. Das Solenidium ω liegt dem Tarsusglied nahezu an. Die Lateral- und Acanthoidborsten sind glatt und kräftig.

Chelicere (Abb. 4): Länge 95 μ , Breite 32 μ (Länge: Breite=3:1). Lateralborste sehr spitz zulaufend, mit 6 langen und kräftigen Fiedern. Flankenborste mit

kurzen Börstchen besetzt. Mediade Flankenversteifung korbartig (familientypisch?). Chelicerentibia länger als -tarsus. Scherenzähne sehr spitz, besonders die Canini des Tarsus; Schere gut aktinochitinisiert. Scherenzahnformel: 1.2.1 1/2/1.2.0.

Bein I (Abb. 5): Alle Borsten (ausser Solenidien, Unguinal- und Subunguinalborsten) an der beinabgewandten Seite mit 2 Zeilen kräftiger Fiederhacken besetzt; am Femur 2v entrale Schwertborsten. Beborstungsformel: $3+2$ (Schwertborsten) $-2+\sigma -4+\phi 1$ (50 μ lang), $\phi 2 - 18+\omega 1, \omega 2, \epsilon$.



Oppia sticta, n. sp.

ABB. 3: Palpe. — ABB. 4: Chelicere. — ABB. 5: Bein I.

Systematik: *Oppia sticta* hat 6 mediane Propodosomaflecken wie *Oppia sexmaculata* Dalenius 1950, unterscheidet sich aber in der Sensillusform und durch das Fehlen von Lamellen von dieser. Von den lamellenlosen *Oppia*-Arten (zB: *O. cyclosoma* und *grandis* Mihelcic 1955, *O. duffyi* Evans 1954, *O. maculata* Hammer 1952, *O. quadrimaculata* Evans 1952 (Forsslund 1953) ist *Oppia sticta* jeweils durch mehrere morphologische Merkmale unterschieden.

Holotypus (zerlegt) in der Zoologischen Staatssammlung München, 1 Paratypoid beim Sammler.

***Oppiella niliaca*, n. sp.**(Fam.: *Oppiidae*)

Habitus: Farbe (n. RIDGWAY 1913): "antimony yellow" (Pl. XV, No. 17, Tone b).

Körperlänge: 224 μ ; Körperbreite: 107 μ .

Dorsale Borsten breit blattförmig, mit deutlichen Längs- und Querlamellen. Ventrale Borsten baumförmig gefiedert oder glatt. Ausgeprägte Chitinstrukturen; grosse, rundliche Poren (Abb. 6-10).

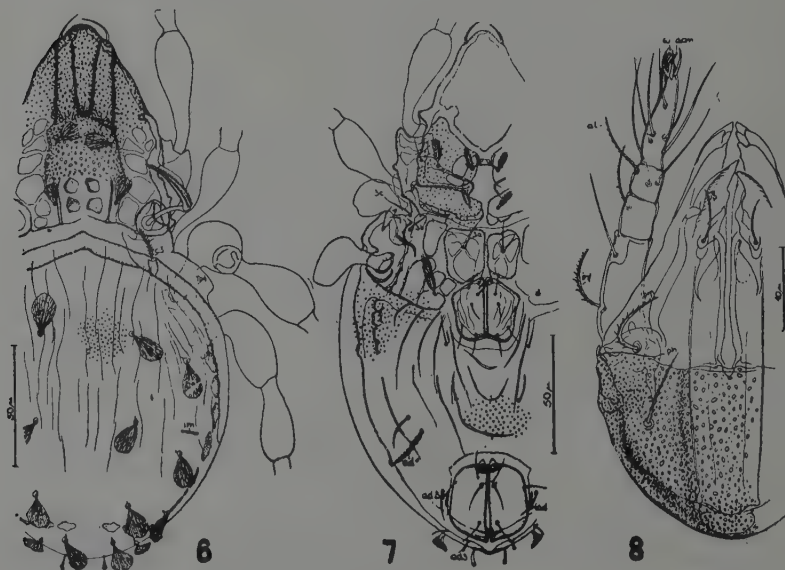
Propodosoma: Mit breiten Lamellen, die sich als sanfte Aufwölbung abzeichnen und die vor den blattförmigen Lamellarborsten aus einem rechteckig geformten Sockel entspringen; verlaufen bis zum Propodosomarand zu Seiten des vorgerrundeten Rostrums und tragen an dieser Randmündung die kräftigen, aussen seitig befiederten Rostralborsten (12 μ lang). Der Lamellensockel läuft nach hinten zu in das Chitinquerband aus, dem die Bothridien aufsitzen und das als Tectopedie IV breit an den Rückenschild ansetzt. 4 mediane, annähernd quadratische Chitinpfannen liegen nahe vor dem Querband; seitlich davon verläuft je eine kräftige Leiste in Körperlängsrichtung. Die Interlamellarblätter sitzen jeweils nahe am Aussenrand dieser Leiste. Zu Seiten des Lamellarsockels mehrere unregelmässig geformte Chitinflecken. Den Propodosomarand bildet bis zur Höhe des Lamellenursprungs ein kräftiger, unregelmässig verlaufender Chitinwulst, der bei der Bothridie entspringt und nach vorne zu einwärts umbiegt. Sensillus auf kräftigem, auswärts gebogenem Stil nach innen geknickt. Auf spitz zulaufendem Sensilluskörper 4 Reihen kurzer Sinneszotten, die von Sekret umhüllt sind.

Epimeralgebiet mit grossen, porenfreien Chitinflecken und sternalen Versteifungsleisten und Bändern. Apodemata schmale Spangen. Borsten nackt oder baumförmig gefiedert. Tectopedie II groß mit abgerundetem Vorsprung (vgl.: Abb. 7).

Hysterosoma: Rückenschild mit spitz zulaufendem Vorderrand, von herzförmiger Gestalt. Schulterborste *c3* ("spur bristle" JACOT 1937) baumförmig gefiedert, in einem Köcher. Medianfissur (*im*) 8 μ lang. Randnahe Muskelansatzstellen als grosse, längliche Flecken ausgebildet. Unregelmässig verlaufende Längslinien bedecken etwas mehr als die vordere Hälfte des Rückenschildes. Der Panzer des ventralen Hysterosomas endet als verstärkte, gewölbte Kante hinter dem 4. Epimeralfeld und umgreift als schmaler Rahmen, der Versteifungen in das 4. Epimeralfeld entlässt und mit dem prosomalen Sternum verschmilzt, den Genitalbereich. Genitalfeld 24 μ lang, 26 μ breit. Genitalfügel mit je 7 nackten Borsten. Analfeld (40 μ lang, 36 μ breit) ohne zusätzliche Umrahmung. Jeder Flügel vorne median mit gerundetem Höcker gelenk; mit je 4 nackten Borsten. Zu Seiten der Genitalfügel je ein Spalt (*iad*). Präanalborste (*ad1*) zweizeilig befiedert. Borste seitlich der Analflügel (*ad2*) glatt. Postanalborste (*ad3*) leicht keulenartig verdickt. Der Bauchpanzer

ist im vorderen Teil durch kräftige Leisten, die bogenförmig vom Genitalfeld ausgehen, versteift.

Gnathosoma (Abb. 8): Hypostom halbkreisförmig gepanzert. Chitin deutlich durch \pm elliptische Poren perforiert. Der Hypopharynx baucht den Panzer mediad vor. Hypostomal (*ph*)- und Supracoxalborste (*pm*) mit wenigen Fiedern auf der körperabgewandten Borstenseite. Coxopoditborste (*pa*) leicht gekörnelt.



Oppiella niliacs, n. sp.

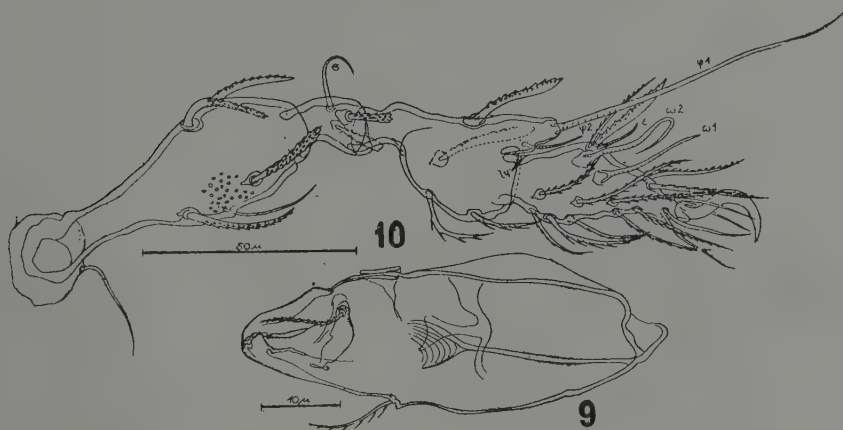
ABB. 6: Dorsalansicht. — ABB. 7: Ventralansicht.

— ABB. 8: Gnathosoma ventral mit Palpe.

Die Palpenborsten sind glatt mit Ausnahme der unteren (*inf*) des Femur, der Genuborste sowie der Antilateralborste (*al*) der Tibia. Diese sind auf der palpabgewandten Seite mehrzeilig beborstelt oder befiedert. Tarsus ohne "Doppelhorn" (vgl. : GRANDJEAN 1946); das klöppelartige Solenidium (von halber Tarsuslänge) ist nicht mit der Anteroculminalborste (*acm*) verschmolzen. Die Acanthoidborsten sind greiferartig ausgebildet und sehr kräftig. Palpenlänge (1-4) 34μ .

Chelicere (Abb. 9): 57μ lang, 18μ breit (Länge: Breite=3:1). Lateralborste (10μ lang) mit 6-8 langen Fiedern. Flankenborste rundum beborstelt. Chelicerenzähne schwach actinochitinisiert. Chelicerentibia (=Digitus fixus) mit breitem Mittelzahn. Chelicerentarsus mit spitzem Hinterzahn.

Bein I (Abb. 10): Länge 102 μ . Schwertborsten mit groben Höckern an der Aussenseite; auf allen Beingliedern (4-2-2-1; st 14 μ lang). Solenidier. G (?) und ω 2 einwärts gebogen. ϕ 1 44 μ lang, ϕ 2 (= ϵ ?) winzig. Ventralborsten von Tibia, Ventral- und Lateralborsten von Tarsus aussenseitig gefiedert, distad beborstelt. — Bein I-IV einkrallig.



Oppiella niliaca, n. sp.

ABB. 9: Chelicere. — ABB. 10: Bein I.

Systematik: Die Art *niliaca* weicht in folgenden Merkmalen von JACOT's *foliosa* ab:

Keine Rostralhöcker — Lamellenbegrenzung deutlicher (auch mediad) — Borsten zu Seiten des Analfeldes (*ad*2) nicht blattförmig — Präanalborste (*ad*1) nicht dünn, sondern kräftig und befiedert — nicht 4, sondern 7 Borsten auf jedem Genitalflügel (Versehen bei JACOT ?) — Epimeralborsten nicht blattförmig, sondern glatt (*3a-c*) oder gefiedert. Dorsalflügelborsten breiter und geädert. — Prosomale Chitinleckung fehlt bei *foliosa* (oder bei JACOT's Beschreibung!). — Versteifungsleisten des hysterosomalen Bauchpanzers fehlen bei *foliosa* (mit Sicherheit!).

Die Art kann auch in die neue Gattung *Mystroppia* BALOGH 1959 gestellt werden. Von dessen monotypischer Art *sellnicki* weicht *niliaca* ab: Durch die geringere Körpergrösse (Länge 224 μ : 283 μ ; Breite 107 μ : 150 μ). Die Interlamellarhaare sind löffelförmig, grob, statt borstig, winzig; dagegen hat *niliaca* Rostralborsten statt Rostralröfchel, auch sitzen jene weiter rostrad als bei *M. sellnicki*. Vor der Basis des Prodorsums gibt es bei *niliaca* nur 2, statt 4 Chitinleisten, dafür 4 Chitinlecken. Davor liegen breite, aufgewölbte Lamellen, statt schmale Leisten.

Die Genitalflügel tragen je 7 statt 4 nackte Borsten, ebenso die Analflügel je 4 statt 2 Borsten. *Ad* 1 liegt vor der Analplatte randnäher und ist borstig behaart,

statt loffelförmig. Auch *ad* 2 ist nur eine glatte, kräftige Borste. Ausserdem ist bei *niliaca* ein Analschlitz (*iad*) vorhanden, der *M. sellnicki* zu fehlen scheint. Kleinere Unterschiede finden sich auch beim Vergleich von Bein I der beiden Arten.

Holotypus (Weibchen; zerlegt) in der Zoologischen Staatssammlung München.

***Oribatula (Zygoribatula) tadrosi*, n. sp.**

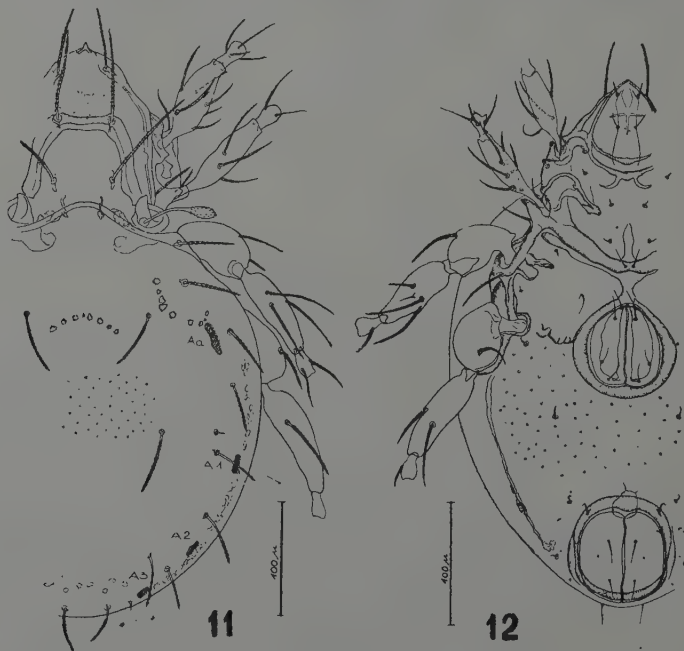
(Fam.: *Oribatulidae*)

Habitus: Farbe (n. RIDGWAY 1913) "ochraceous-tawny" (Pl. XV, Nr. 15, Tone i).

Körperlänge: 498-502 μ ; Körperbreite: 311-322 μ .

Borsten regelmässig beborstet (ausser Solenidien der Beine) (Abb. 11-15).

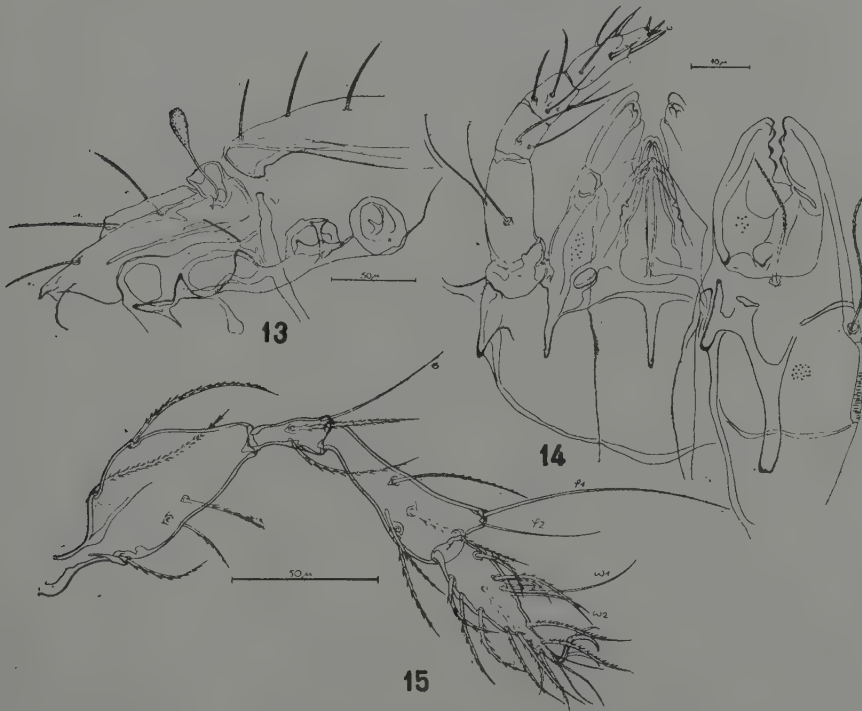
Propodosoma: Feine Chitinporen dorsal und ventral. Deutliche Rostrumspitze (vgl.: *Systematik*). Lamellen zur Aussencuspis hin zusammenlaufend, Translamelle 14 μ breit. Aussencuspis undeutlich, Innencuspis schwach zugespitzt. Abstand der Innencuspis: 40,6 μ , Abstand der Aussencuspis: 53,1 μ . Lamellarhaar 90,4 μ lang, Abstand voneinander: 47 μ . Translamellarhaar 102 μ lang, Abstand voneinander: 59 μ . Rostralhaar 60 μ lang. Tutorium randnah, Chitinverstärkung ohne



Oribatula (Zygoribatula) tadrosi, n. sp.

ABB. 11: Dorsalansicht. — ABB. 12: Ventralansicht.

Profil. Bothridie mit stumpfen, nach aussen gebogenem Höcker, Sensillus 62 μ lang, keulig verdickt, mit spitzen Börstchen besetzt (Abb. 13). Mentotectum deutlich, mit nach aussen gebogenen Apodemen 1. Apodemen 2 mit Epimeren 2 wenig zur Körpermitte vorspringend. Jugalapodemen als breites, durch Epimeren 3 mit Genitalfeld verbundenes Band über die Ventralseite ausgebildet. Apodemen 3 noch kürzer als 2, Epimeren 4 nicht mit Gelenkpfanne 4 verbunden, nur angedeutet. Tectopeden I nach vorne weisend, gerundet, Tectopeden II kräftig, spitz.



Oribatula (Zygoribatula) tadrosi, n. sp.

ABB. 13: Propodosoma (Flankenansicht). — ABB. 14: Gnathosoma ventral mit Palpe und Chelicere. — ABB. 15: Bein I.

Hysterosoma: Vorderrand zwischen den Bothridien nach vorne ausgebuchtet. Schulterecken schmal, schwach rundlich vorspringend. Bogenförmig angeordnete, sternartige Chitinverdünnungen als Muskelansatzstellen (Milchsäurebehandlung oder Trypsinverdauung !) (Abb. 11).

Areae: Aa langgestreckt; Länge: 25,1-31,6 μ ; A1 Länge: 11,5-20,3 μ ; A2 Länge: 8,1-12,4 μ ; A3 Länge: 8,1 μ .

Genitalfeld mit breiter, kräftiger Chitinumrahmung, vorne stielförmig mit Epimeren 3 vereinigt. Analplatte mit deutlicher Chitinumrahmung. Ventralbeborstung kurz, kräftig; Genital- und Analplatten mit längeren dünneren, nackten Borsten. Genitalplatte: grösste Länge (mit Umrahmung): 53,11 μ (73,4 μ); grösste Breite (mit Umrahmung): 50,8 μ (73,4 μ). Analplatte: grösste Länge: 79,1 μ ; grösste Breite: 84,7 μ .

Abstand zwischen Genitalplattenhinterrand und Analplattenvorderrand 231 μ .

Systematik: Von *Oribatula* (*Zygoribatula*) *setosa* EVANS 1953, die dieser aus einer Milbenaufsammlung vom Kilimanjaro (Tanganyika) beschreibt, weicht *tadrosi* n.sp. wie folgt ab: 1. Grössenunterschied: Länge: 4,4-5, Breite: 2,8-3; 2. Lamellenaussenrand: leicht konkav-deutlich konvex; Lamellen setzen vor den Bothridien eingeschnürt ab; 3. Bothridie: rundlich — mit zipfelförmigem Innenhöcker; 4. Areae porosae: elliptisch — langgestreckt; 5. Rostrumspitze: schmale Papille — deutlicher Zapfen.

Gegenüber *Zygoribatula rostrata* Jacot bestehen folgende Unterschiede: Areae porosae: rundlich — langgestreckt; Rückenborsten: dünn, glatt — kräftig, beborstet; Körpergrösse: *rostrata* < *setosa* < *tadrosi*.

Holotypus in der Zoologischen Staatssammlung München; Paratypepoide beim Sammler (10) und in der Zoologischen Staatssammlung (20).

PLAKORIBATES, n. gen.

Name: Plax,kos — gr. Plättchen, Lamelle; oros — gr. Berg; bainein — gr. gehen.

Systematik: Verwandt mit *Tectoribates* I und II (= *Ophidiotrichus* nom. nov.) sensu GRANDJEAN 1953, *Oribatella* Banks 1895, *Anachipteria* Grandjean 1932 und *Joelia* Oudemans 1906 (= *Coggiella* Berlese 1916); gehört zur Familie *Oribatellidae* Jacot 1925.

Habitus: Die Lamellen bedecken nahezu das ganze Propodosoma, ragen über den Rostrumrand und haben einen unversteiften Aussenrand, der nicht ausschliesslich eine Aussencuspis ausbildet. Die Lamellarborsten entspringen kräftigen Versteifungen des Lamelleninnerrandes. Eine Lamellenverschmelzung tritt höchstens knapp vor dem Vorderrand des Rückenschildes ein. Interlamellarborsten kräftig und lang. Pteromorphen ausladend, nach hinten gegen den Rand des Rückenschildes abgesetzt, mit gerundeter Vorderecke, die die Höhe des Rückenschildvorderrandes nicht erreicht. Bau des Gnathosoms nicht *Pelops*-ähnlich (vgl.: GRANDJEAN 1932). Körpernahe Beinglieder mit ventralen Kielen. 3-krallig.

Typus: *Plakoribates multicuspidus*, n.sp.

Plakoribates multicuspidus, n. sp.

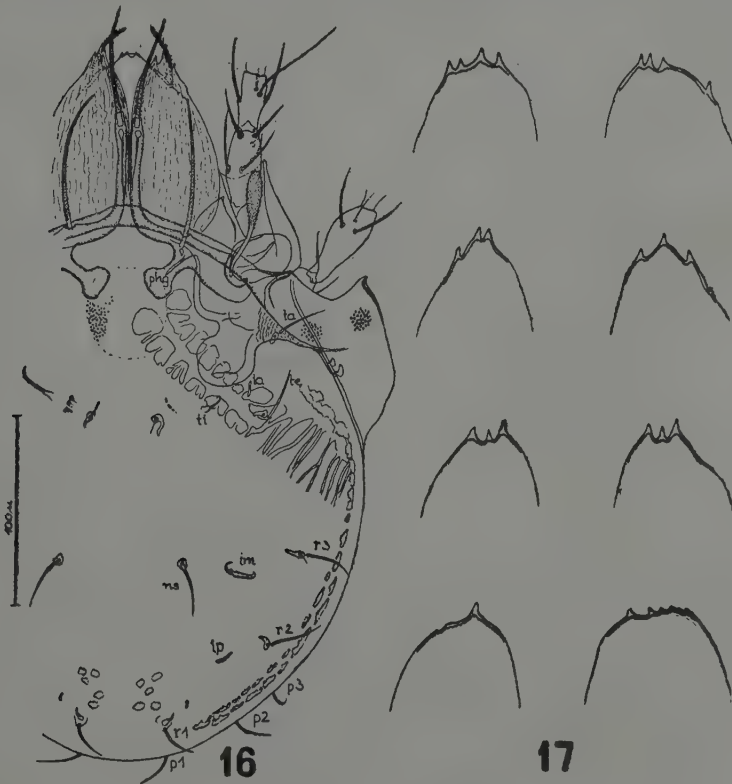
(Fam.: *Oribatellidae*)

Habitus: Farbe (n. RIDGWAY 1913) "cinnamon-brown" (Pl. XV, Nr. 15, Tone k).

Länge ohne (mit) vorstehende Lamellen: 356 μ (370 μ); Breite: 270 μ . (Abb. 16-23).

Vgl. Gattungsbeschreibung.

Propodosoma: Die Lamellen (grösste Länge 73,4-79,1 μ ; grösste Breite 39,5 μ) sind dünne, längsgeäderte Platten, die etwa 15 μ über den Propodosomarand vorstehen. In Höhe von Tectopodie 1 biegt sich der unverstärkte Aussenrand mediad einwärts. Die Zahl der Cuspes der Lamelle schwankt (bei den mir vorliegenden 14 Exemplaren) zwischen 1-5; ihre Lage am Lamellenvorderrand, ihre Grösse sowie

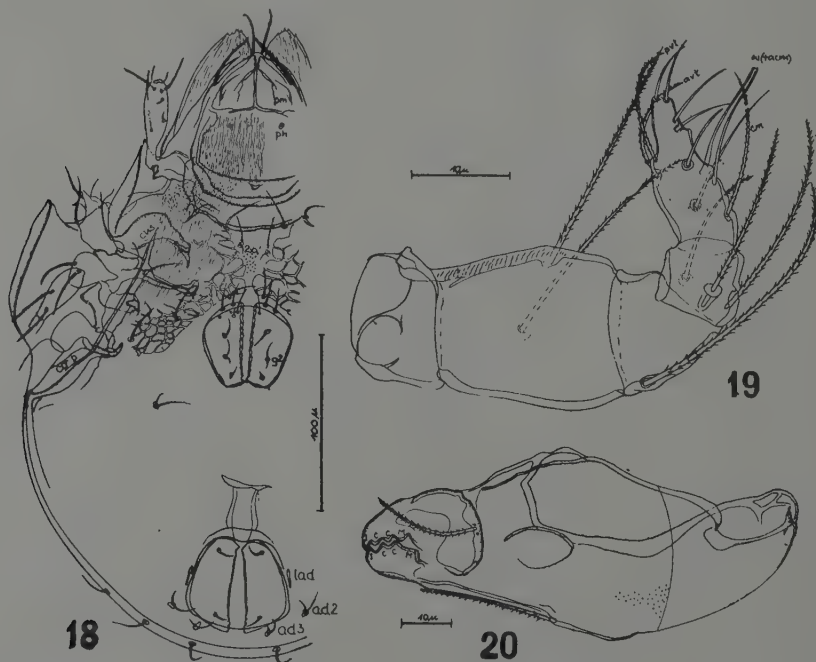


Plakoribates, n. gen., *multicuspoides*, n. sp.

ABB. 16: Dorsalansicht. — ABB. 17: Variation der Lamellencuspes jeweils eines Lamellenpaares.

gegenseitige Ausbildung an den beiden Lamellen eines Tieres ist weit variabel (vgl.: Abb. 17). Die Innenränder der Lamellen nähern sich einander am Ursprung der fein beborsteten Lamellarborsten (Länge 50,8 μ) aus kräftig rundverstärkten Chitinleisten, die unter dem Vorderrand des Rückenschilds in Richtung der Bothridien

umbiegen. Zwischen Umbiegungsstelle und Bothridienköcher insertiert die beborstelte Interlamellarborste (Länge 62-68 μ). Hinter dieser Insertionsstelle springt eine klöppelartige innere Lamelle (*phg*) schräg mediad in den Bauchraum vor. Das gerundete Rostrum ist mit einigen, dorsal sichtbaren Spitzchen besetzt und trägt beborstelte Rostralborsten (Länge 40 μ). Zwischen Interlamellarhaar und Bothridie sitzt dem Vorderrand des Rückenschilds ein dünnes, etwas durchsichtiges Plättchen von asymmetrischer Blattform an, das ich für das Tutorium halte. Auch die Bothridienmuschel bildet einen blättchenartigen Vorsprung aus. Der Sensillus zeigt nach vorn, ist keulenartig verdickt und mit winzigen Börstchen besetzt (Länge 51 μ).



Plakoribates, n. gen., *multicuspidus*, n. sp.

ABB. 18: Ventralansicht. — ABB. 19: Palpe. — ABB. 20: Chelicere.

Das ventrale Propodosoma ist längsliniert bis zum Beginn des eigentlichen Bauchpanzers. Im Bereich von Apodema 1 zeigt sich ein Linienwirbel, der von feinen, mitunter tropfenförmigen Poren durchmischt ist. Das Gnathosoma trägt 2 Paar Borsten (*ph*, *pm*). Tectopedium 1 läuft in einen mediad gebogenen Spiess aus, der fast bis zur Rostrumspitze reicht. Das Mentotectum ist kräftig und breit. Apodema

1 entspringt im Bereich des Gnathosomagelenks, biegt dann aber in weitem Bogen vom Mentotectum als schmale Chitinspange mit jederseits 2 dornartigen Fortsätzen ab. Tectopedium II pteromorphenförmig, mit vorspringender Aussenecke. Apodema 2 kurz, mit Schnabelfortsatz, der nach hinten weist. Tectopedium III höckerartig. Apodema zwischen 2 und 3 ("sejugal" bei GRANDJEAN 1952) schmal, mit verbreitertem Fortsatz; bis zur halben Körpermitte reichend. Discidium gleichschenklige dreieckig. Apodema 3 kurz, kommaförmig. Apodema 4 kurz, mit nach vorne gebogenem Fortsatz. Ein schmaler Grat (*cir. p.* = "arête circumpedicuse" bei GRANDJEAN 1952) entspringt aus dem Ventralrand des Hysterosomas und zieht ziemlich gerade mit einem Custodium (*cus*) bis zum Acetabulum 2. Sternum unsymmetrisch ausgebildet; mit Gitterwerk, das in die Epimeralfelder vorspringt. Epimeralborsten fein beborstelt oder glatt (*2a'* auf Sternum).

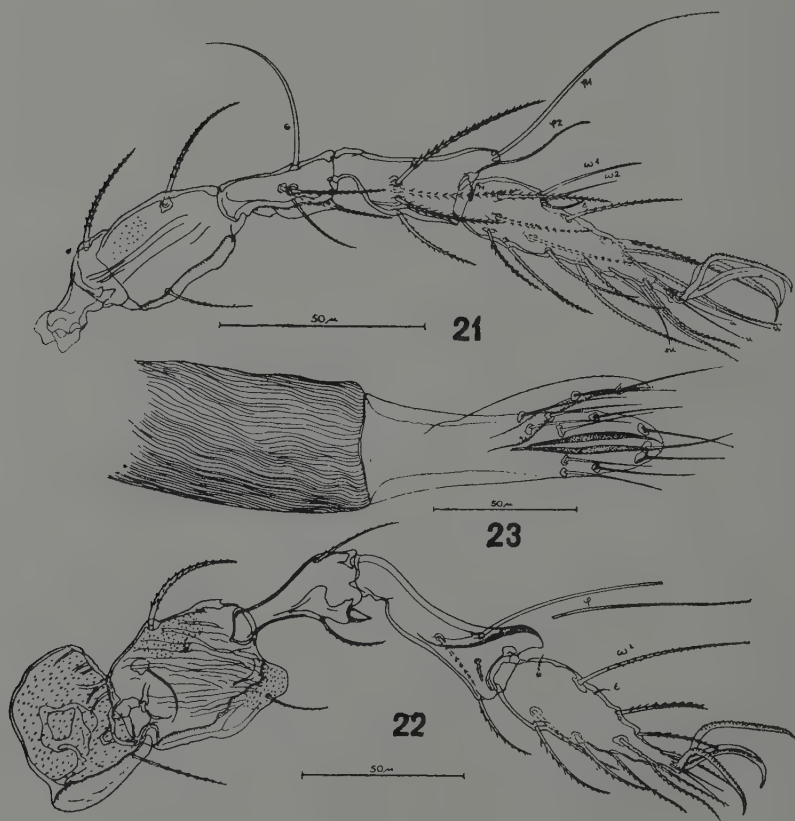
Hysterosoma: Der Rückenschild überdeckt mit seinem konvex ausgebogenem Vorderrand den unteren, auswärts gebogenen Teil der Chitinleiste, der die innere Lamelle (*phg*), die Bothridie und die Interlamellarborste aufsitzen. Pteromorphen klein, mit Aussenspitze, die bis zur Höhe der Schulterecke reicht. Ansatzbreite der Pteromorphen am Rand des Rückenschildes 118,6µ. Im vorderen Teil des Schildes ein runder, hellerer, medialer Chitinfleck mit feinen Poren. Von dort zieht schräg nach aussen-hinten eine Chitinstruktur, die sich bis zur Borste *te* als eine Doppelreihe unregelmässig eingeschnittener Flecken, von *te* bis zum Schildrand als einfache Rillung darstellt. Muskelansatzflecken nahe am Schildrand, vorne einreihig, etwa ab Borste *r3* zweireihig bis *r1*.

Rückenborsten nackt, spitz; auf oder neben Chitinsockeln oder -spangen wahrscheinlich die Öffnungsschlitze von Atemsäckchen (vgl.: GRANDJEAN 1950: "sacculs respiratoires internes"). Pseudofissuren (*ia*, *im*, *ip*) längsgestreckt. Der hysterosomale Bauchpanzer ist glatt, Genital- und Analfeld ohne zusätzliche Umrahmung. Genitalfeld 58µ breit, 49µ lang. Jeder Genitalflügel mit mindestens 6 nackten Borsten; *g2* als Doppelborste auf gemeinsamen Höcker. Medianrand der Genitalflügel mit etwa 12 Kerben. Analfeld 76µ lang, 62µ breit. Jeder Analfeldflügel mit 2 nackten Borsten; hinterer Teil des Medianrandes mit Nut-Feder-Zähnung. Präanalborste fehlt, Doppelborste (*ad2*) an der hinteren Aussenbucht des Analfelds, Postanalborste (*ad3*) einzeln oder mit kleiner Dornborste auf gemeinsamer Borstenplatte. Adanalspalt (*iad*) 10µ lang.

Palpe (Abb. 19): Gedrungen. Borstenformel: 0-2-1-3-11. Alle Femur-, Genu- und Tibiaborsten stark beborstelt, ferner die Culminal (*cm*), die Para- und Antiventralborsten (*pvt*, *avt*) des Tarsus. Das Solenidium ω scheint mit der Anteroculminalborste (*acm*) zu einem einheitlichen breiten Zapfen vereinigt.

Chelicere (Abb. 20): Länge 90µ, Breite 20µ (Länge: Breite=4,5:1). Lateralborste (dorsal in situ !) liegt eng an der Chelicerentibia an und ist auf der abgewandten Seite mehrzeilig beborstelt. Flankenborste rundum(?) beborstelt. Scherenzahnformel: 1.2.1/1.2.0; schwache Actinochitinisierung.

Bein I (Abb. 21): Alle Borsten (ausser Solenidien, Unguinal- und Subunguinalborsten) an der beinabgewandten Seite 2- bis mehrzeilig beborstelt. Beborstungsformel: $3-3+6-\sigma+\phi 1$ (96 μ lang), $\phi 2-18+\omega 1$, $\omega 2$, ϵ . Femur und Genu mit ventralem Kielblatt.



Plakoribates, n. gen., *multicuspidus*, n. sp.

ABB. 21: Bein I. — ABB. 22: Bein IV. — ABB. 23: Ovipositor ausgestülpt.

Bein IV (Abb. 22): Trochanter und Femur stark verdickt, gedrungen; mit breiten, ventralen Kielblättern. Genu mit kräftigem ventral-distalem Zapfen, Tibia mit dorsal-distalem Bug.

Beborstungsformel: $(1)-2-2+\text{Zapfen}-3+\phi-12+\omega$, ϵ .

Alle Beine dreikrallig. Seitenkrallen dorsal mit winzigen Höckern besetzt.

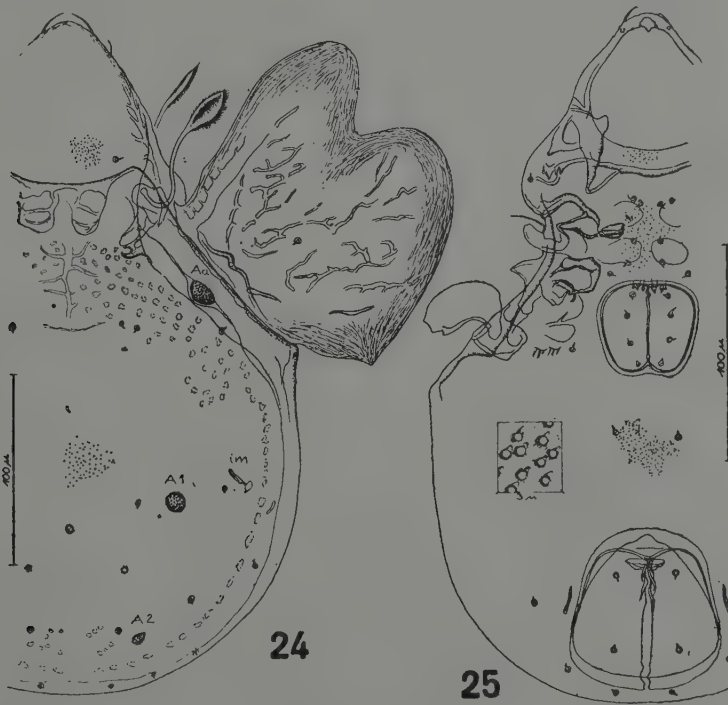
Holotypus in der Zoologischen Staatssammlung München; Ovipositor (Abb. 23) von einem Paratypoid. Paratypoiden beim Sammler (25) und in der Zoologischen Staatssammlung (25).

***Allogalumna exigua*, n. sp.**

(Fam.: Galumnidae)

Habitus: Farbe (n. RIDGWAY 1913) "auburn" (Pl. II, Nr. 11, Tone m).

Körperlänge: 345 μ ; Körperbreite: über Hysterosoma 219 μ , am Pteromorphenansatz 258 μ .



Allogalumna exigua, n. sp.

ABB. 24: Dorsalansicht. — ABB. 25: Ventralansicht.

Körperborsten dornförmig, auf kräftigen Chitinsockeln. Petromorphen gut beweglich, in Aufsicht Aussenrand tief eingekerbt. Körperoberfläche mit sehr feinen, unregelmässig verdichteten Chitinporen (Abb. 24-28).

Propodosoma: Dorsal ohne Skulptur (ausser Poren). Rostrum sehr stark gerundet, Rostralborste kräftig. Keine Lamelle; an dieser Stelle verzweigte Skulpturierung des Propodosoma-Randes erkennbar. Lamellarborste von halber Länge des Rostralhaares. Interlamellarborsten dornförmig, Abstand voneinander 56 μ .

Mentotectum schmale, kräftige Chitinspange; mit der Innenwand von Acetabulum I verwachsen. Diese setzt sich über das Mentotectum hinaus als Bügel fort und trägt einen kräftigen Gelenkhöcker für das Gnathosoma. Tectopedium II schliesst Tp. I ein; mit Borstendorn. Acetabulum II mit kräftiger Wandung und nahe zur Körpermitte reichendem Apodema 2; am medianen Endstück epimerale Verbreiterung. Tectopedien III und IV gattungstypisch. Acetabulum III mit abwärts gebogenem, kurzem Apodema. Acetabulum IV ohne Apodema. Zwischen Mentotectum und Genitalfeld zwei Paar elliptische, distad selten geschlossene, hellere Flecken schwächeren Chitins, ebenso im 4. Epimeralfeld zwei distad offene Flecken auf jeder Körperhälfte (Abb. 25). Bothridie vom Vorderrand des Rückenschildes verdeckt, kelchförmig. Sensillus spatelförmig, Randbefiederung; dabei der stärker gebauchte Hinterrand dichter und länger befiedert (Abb. 24).

Hysterosoma: Ausgeprägter, konkaver Vorderrand mit zwei nach hinten weisenden, sackförmigen Chitinstrukturen. Pteromorphenansatzrand leicht konkav, mit zwei gerundeten Ecken.

Pteromorphen mit unregelmässig verlaufenden Versteifungen. Nahe am und parallel zum Vorderrand eine breite Leiste mit Randabzweigungen. Zwei Pseudofissuren in Hinterrandnähe. Gesamtlänge 158 μ , Ansatzrand Länge 90 μ . Grösste Breite 102 μ , Breite an der Einbuchtung 79 μ ; Areae rund bis elliptisch: *Aa* Länge 12 μ , *A1* (mesal-mesonotal) Durchmesser 8 μ , Pseudofissur (*im*) 8 μ , *A2* (lateral-mesonotal) Durchmesser 7 μ . Rückenschild mit sternförmigen Chitinverdünnungen, randnah, nach vorn zu zu mehreren Reihen gehäuft. Auf der Höhe von *A1* medial ein deutlicher Porenkranz, ebenso zwischen *A1* und *A2* auf beiden Seiten.

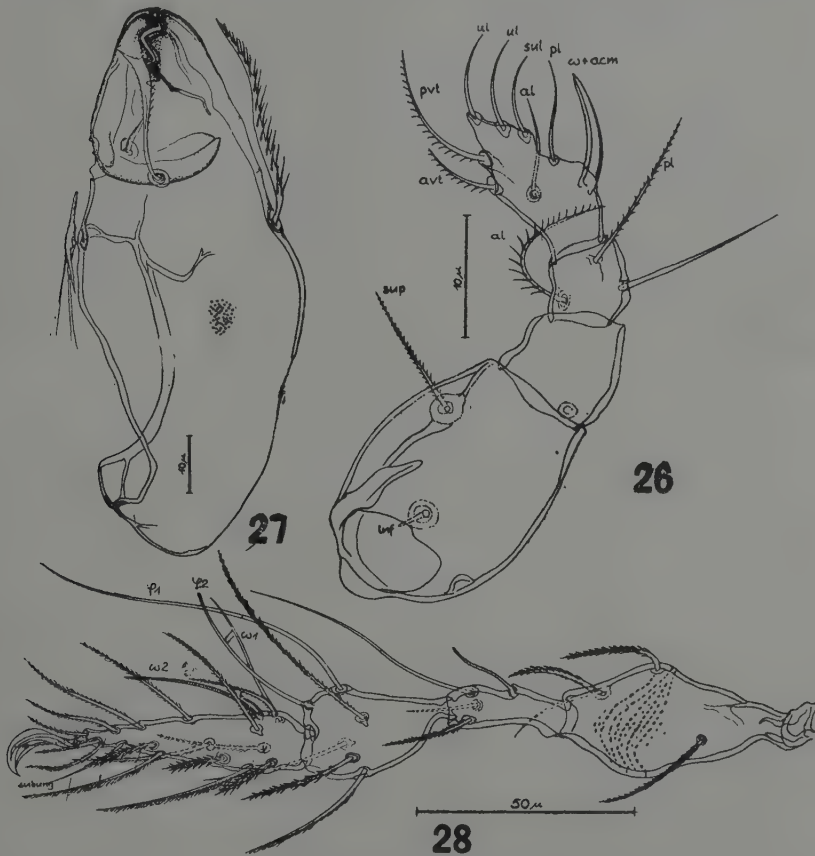
Genitalfeld (Länge 37 μ , Breite 45 μ) schmal umrahmt. Jeder Genitalflügel mit einer Reihe von 4 Dornborsten; vordere, mediane Ecke mit zwei Insertionsstellen (?) und 3 feinen Tasthaaren in Gruben. Analfeld (Länge 64 μ , Breite 73 μ) vorne breit umrahmt. Jeder Analflügel mit zwei Dornborsten. 2 lange (8 μ) Pseudofissuren zu seiten des Analfelds. Abstand Genitalfeld-Hinterrand bis Analfeld-Vorderrand 79 μ .

Palpe (Abb.: 26): Länge 42 μ (vom Femurgelenk aus). Borsten von Femur (*sup*, *inf*), Genu (nur Insertionsstelle erhalten, wahrscheinlich wie Femur) und Tibia (*pl*) rundum beborstelt. Die Antilateralborste von Tibia sowie die Para- und Antiventralborste von Tarsus (*pvt*, *avt*) einseitig gefiedert. Ultimale Acanthoidborsten (*2ul*, *subul*) gleichsinnig gebogen, spitz, glatt. Para- und Antilateralborsten des Tarsus glatt. "Doppelhorn" (GRANDJEAN 1935) aus Solenidium und Anteroculminalborste verschmolzen (?), zapfenartig.

Chelicere (Abb. 27): Länge: Breite=2,4:1; Gesamtlänge 98 μ . Lateralborste breit, mit kräftigen, langen Börstchen böesetzt. Flankenborste distad flügelartig

verbreitert, mit wenigen, kurzen Borsten am Rande besetzt. Scherenvorderrand und -zähne auffallend stark actinochitinisiert.

Systematik: *Allogalumna exigua* steht *Zetes minutus* JACOT 1935 (wahrscheinlich *Oribata minuta* EWING 1909) sehr nahe. In folgenden Merkmalen unterscheiden sich beide Arten: (*Z. minutus*-*Allog-exigua*):



Allogalumna exigua, n. sp.

ABB. 26: Palpe. — ABB. 27: Chelicere. — ABB. 28: Bein I.

Lamelle als leichte Aufwölbung erkennbar — keine Lamelle. Genitalflügel: 2 Borsten — > 2 Borsten. Pseudofissuren seitlich des Analfeldes: fehlen — vorhanden. Vorderrand des Rückenschildes ("midthoracic suture"): schwach ausgebildet, nach vorne konvex ausgebogen, oft gewellt — sehr deutlich ausgebildet, konkav.

Pteromorphen: ohne Aderung — auffallende Verstärkungsleisten. Tarsus I (Abb.28): Nur primiventrale Schwertborsten sind mit wenigen, langen Fiedern besetzt — alle Borsten (ausser ϵ , ϕ , ω und subung) allseitig behorset oder einseitig mehrzeilig befiedert.

Holotypus (Weibchen; zerlegt) in der Zoologischen Staatssammlung München, 1 Paratypoid beim Sammler.

SUMMARY

An account is given of five Oribatid mites collected by MOHSEN S. TADROS, Cairo, on a cultivated landstrip at Giza (West bank of the Nile). The following genus and species new to science are described: *Oppia sticta*, *Oppiella niliaca*, *Oribatula* (*Zygoribatula*) *tadrosi*, *Plakoribates multicuspidus*, *Allogalumna* (*Akrogalumna*) *exigua*.

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**HOST-PLANTS FAVOURED
BY THE COTTON LEAF-WORM MOTH,
PRODENIA LITURA F., FOR EGG-LAYING,
AND THEIR VALUE AS EGG-MASS TRAP-CROPS**

[*Lepidoptera: Agrotidae-Zenobiinae*]

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(with 4 Text-Figures and 8 Tables)

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INTRODUCTION

The nature of relationship between phytophagous insects and their hosts has long been disputed. VERCHAFFELT (1910) was the first to suggest that it was neither botanical nor nutritional, but was of a chemical nature, and that odour was the main influencing factor of host selection. Other workers on different insects (MC COLLOCH, 1922; MOORE, 1928; MC INDOO, 1935; and DETHIER, 1947) subsequently substantiated. VERSCHAFFELT's hypothesis.

Prodenia litura F., the major polyphagous insect pest in Egypt, attacking more than 60 different cultivated and wild plants, needs extensive bio-chemical and botanical investigations to verify this relationship. These investigations should be preceded by basic ecological studies to get information about the host-plants most preferred by the moth for egg-laying and for larval feeding. Determination of the host-plants preferred for egg-laying by the ovipositing females under field conditions was one of the objects of the present work. At the same time, the host-plants were arranged according to their importance as ovipositing sites, to decide upon their economic value as egg-mass trap-crops in cotton fields. In other words, the other object of this investigation was to test the possibility of using the host

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selection phenomenon as means of control. By application of suitable experimental design and statistical methods of analysis, these objects could be ascertained.

A number of plants commonly known to be heavily infested by the cotton worm, were chosen for investigation on the basis of their similarity in type of growth and date of sowing.

Experimental methods and technique

The experiment was carried out simultaneously, in two different localities, viz: experimental farm of the plant breeding section, Ministry of Agriculture, Giza: and the farm of the Ministry of Agriculture at Sakha, about 100 miles north of Cairo; in square areas of approximately 4000 m.² (slightly less than feddan) and 5600 m.² (about 1¹/₃ feddan), respectively (Figs. 1 and 2).

The following host plants were chosen for the test: cotton (*Gossypium barbadense* L.), cowpea (*Vigna sinensis* Endl.), castor oil plant (*Ricinus communis* L.), maize (*Zea mays*), and sunflower (*Helianthus annuus* L.).

For certain technical restrictions imposed by the Plant Breeding Section (Giza) on growing sunflower plants in the neighbourhood of their experimental farm, the sunflower plant was tested in Sakha Farm only.

Treatments and replicates

For the "trap-crop" tests, cotton was regarded as the main crop. Rows of other host-plants were distributed singly among cotton rows at a varying density ranging between 2:1 and 6:1 (the 2:1 treatment was eliminated from the Giza experiment, and the 4:1 from Sakha experiment).

All treatments (2:1, 3:1, etc.) with every host-plant, were replicated 4 times throughout the experimental area in both localities. The repetitions were arranged in the field as shown in Figures 1 and 2. The number of rows of the secondary host-plants was fixed at 4 in Giza and 5 in Sakha for every treatment and a vacant belt row was left between each two treatments and around the experimental area. Although the Sakha experiment was carried out in the center of a large cotton area yet three "cotton check" plots were incorporated in the experimental area. In the Giza experiment a 5 rows deep belt of cotton was grown around the experiment and served at the same time as a "cotton check" plot.

Sowing dates

The cotton seeds were sown at Giza, on 12.iii.1956, and at Sakha, on 31.iii.56, at practically the same dates for normal cotton cultivation in the locality. The seeds of the other host-plants, however, were sown at Giza, on 5. iv. 1956, and at Sakha, on 24.iv.1956, in their designed rows nearly 3 weeks later, i.e. just before the first cotton watering. This step had to be taken owing to the slower growth of the cotton seedlings and in order to gain uniformity in the height, size and succulence of all host-plants at the time of the main attack of the pest (about June).

C O T T O N B E L T			
6C:1C _r	3C:1C _p	4C:1M	5C:1C _r
6C:1M	3C:1C _r	4C:1C _p	5C:1M
6C:1C _p	3C:1M	4C:1C _r	5C:1C _p
4C:1C _r	5C:1C _p	6C:1M	3C:1C _r
4C:1M	5C:1C _r	6C:1C _p	3C:1M
4C:1C _p	5C:1M	6C:1C _r	3C:1C _p
5C:1C _r	6C:1C _p	3C:1M	4C:1C _r
5C:1M	6C:1C _r	3C:1C _p	4C:1M
5C:1C _p	6C:1M	3C:1C _r	4C:1C _p
3C:1C _r	4C:1C _p	5C:1M	6C:1C _r
3C:1M	4C:1C _r	5C:1C _p	6C:1M
3C:1C _p	4C:1M	5C:1C _r	6C:1C _p
C O T T O N B E L T			

C=cotton C_p=cowpea M=maize C_r=castor

Fig. 1: Density and distribution of host-plant (Giza experiment).

COTTON FIELD			
6C:1M	2C:1C _r	3C:1S	5C:1C _p
5C:1S	6C:1C _p	2C:1M	3C:1C _r
3C:1M	5C:1C _r	6C:1S	2C:1C _p
2C:1S	3C:1C _p	5C:1M	5C:1C _r
C O T T O N C H E C K			
6C:1C _p	2C:1M	3C:1C _r	5C:1S
5C:1C _r	6C:1S	2C:1C _p	3C:1M
3C:1C _p	5C:1M	6C:1C _r	2C:1S
2C:1C _r	3C:1S	5C:1C _p	6C:1M
C O T T O N C H E C K			
6C:1S	2C:1C _p	3C:1M	5C:1C _r
5C:1M	6C:1C _r	2C:1S	3C:1C _p
3C:1S	5C:1C _p	6C:1M	2C:1C _r
2C:1M	3C:1C _r	5C:1S	6C:1C _p
C O T T O N C H E C K			
6C:1C _r	2C:1S	3C:1C _p	5C:1M
5C:1C _p	6C:1M	2C:1C _r	3C:1S
3C:1C _r	5C:1S	6C:1C _p	2C:1M
2C:1C _p	3C:1M	5C:1C _r	6C:1S
COTTON FIELD			

Fig. 2: Density and distribution of host-plant (Sakha experiment).

The same cultural treatments such as manuring irrigation, hoeing etc... were applied to the whole experimental area.

Collection of data

The egg-masses of *Prodenia litura* F. were hand-picked almost daily throughout June, July and August and a record for every single row was kept separately. A specially trained team of labourers and laboratory assistants carried out this task.

Analysis of data

The daily mean number of egg-masses per row was first calculated separately for all host plants in different treatments (2:1, 3:1, etc.) during each of the three months. This grouping of the data in long term means gives a better presentation of comparable data and, in addition, reduces the experimental error to a minimum. Means are shown in Tables I to VI. The means for the cotton rows in different plots of the secondary host-plants are incorporated in the tables for comparison. The tables also show the calculated analysis of variance and the least significant difference "L.S.D." between the means of different host-plants. The figures in Table V, however, were rather small and close to each other that the working out of an analysis of variance was obviously unnecessary.

Discussion of the results

The general infestation of *Prodenia litura* F. in the Giza area showed a maximum in June (Fig. 3). A remarkable drop in the mean number of egg-masses for this area occurred in July and August. At Sakha, the infestation was, on the whole, comparatively small in June and increased considerably during July and August (Fig. 4).

The rate of oviposition on the different host-plants

A uniformity in this rate on similar host-plants could be observed in both experimental areas. It differed greatly, however, from one host-plant to another as could be seen in each of Figures 3 and 4, separately. The following discussion of the results for the different individual host-plants will further emphasise this point.

(a) Castor oil plant

The mean-number of egg-masses per row of host-plant given in Tables I, II, III, IV and VI indicated that the cotton leaf-worm moth showed a distinctive preference for ovipositing on castor oil plants. In all cases the figures for this plant were much higher and significantly different from other hosts. Although it attracted the ovipositing moths, the castor oil plant failed to produce any conspicuous reduction in the infestation on adjacent cotton. This becomes obvious if the means of the cotton rows within the castor plots were to be compared with the corresponding

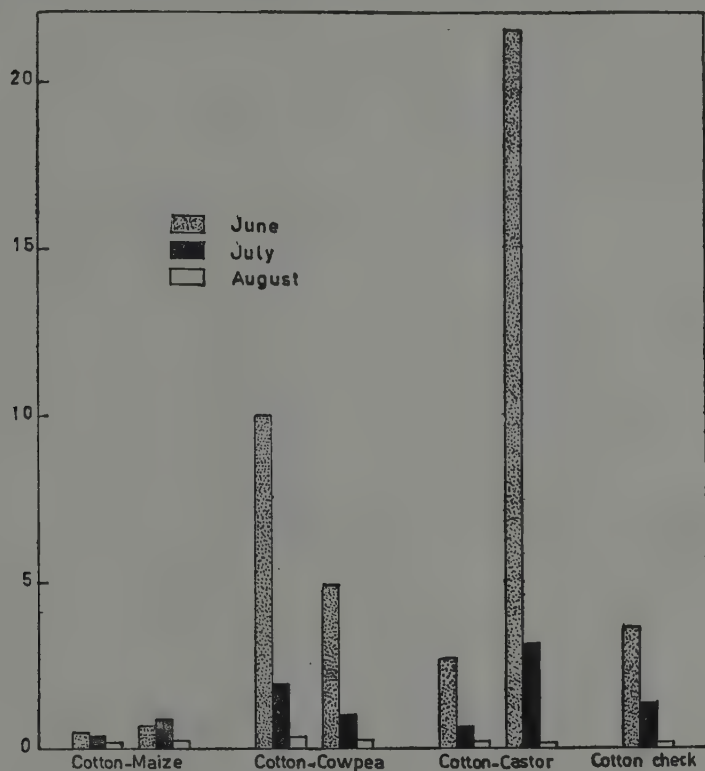


FIG. 3: Mean number of egg-masses per row of host-plant (Giza experiment).

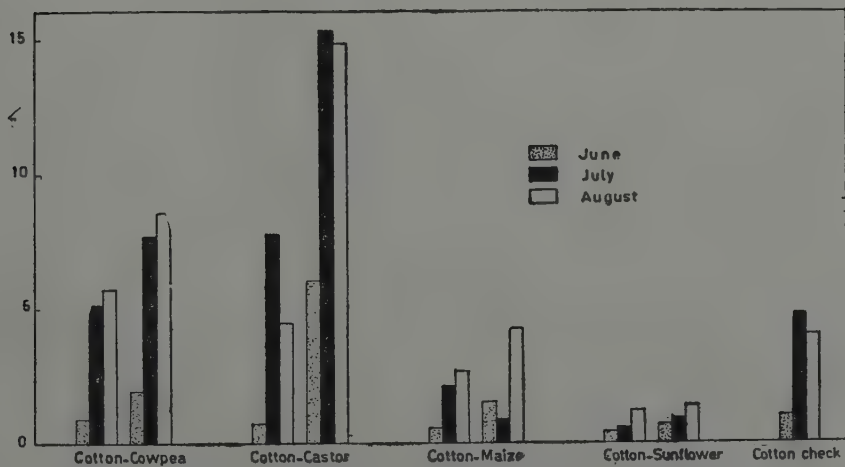


FIG. 4: Mean number of egg-masses per row of host-plant (Sakha experiment).

TABLE I

Giza experiment (June 1956). — Daily mean number of egg-masses per row of host-plant

Treatment	Cotton in maize	Maize	Cotton in cowpea	Cowpea	Cotton in castor	Castor	Cotton check	Total	Mean
3:1	0.30	0.40	10.30	6.30	2.50	5.30	3.60	28.70	4.10
4:1	0.55	0.40	10.45	4.40	2.70	49.50	3.60	71.60	10.23
5:1	0.44	1.00	9.70	5.20	3.36	27.80	3.60	51.10	7.30
6:1	0.58	1.00	9.60	3.80	2.16	3.11	3.60	23.85	3.41
Total	1.87	2.80	40.05	19.70	10.72	85.71	14.40	175.25	—
Means ...	0.47	0.70	10.01	3.92	2.68	21.43	3.60	—	—

ANALYSIS OF VARIANCE

Variance due to	d.f.	SS.	M.S.	F.	P.
Hosts.....	6	1321.10	220.18	3.24	0.05—0.01
Treatments	3	207.45	69.15	1.02	—
Residue	18	1222.47	67.89	—	—
Total	27	2750.62	—	—	—

L.S.D. = 8.24

means of "cotton check" in the above-mentioned tables. It is likely that, with a different method of distribution, e.g. growing castor oil plants around the cotton field instead of few rows scattered within it, this host-plant may prove to be a better trap-crop for the insect. An experiment has been planned for further investigations in the near future.

(b) Cowpea

Although the means of the egg-masses on cowpea were not always significantly higher than those of maize, sunflower plants or "cotton checks" yet the histograms in Figures 3 and 4 indicate that this host-plant is next to castor oil plant in preference of ovipositing moths. On the other hand, cowpea seemed to cause aggregation of the moths on the adjacent Cotton rows, thus increasing the means of egg-masses on cotton. This increase on the cotton plants grown in the cowpea

TABLE II

Sakha experiment (June 1956). — Daily mean number of egg-masses per row of host-plant

Treatment	Cotton in Sunflower	Sunflower	Cotton in cowpea	Cowpea	Cotton in castor	Castor	Cotton in maize	Maize	Cotton check	Total	Mean
2:1	0.28	0.42	0.21	0.85	0.64	4.80	0.43	1.60	0.99	10.22	1.14
3:1	0.13	0.70	0.70	2.80	0.45	6.30	0.40	2.30	0.99	14.77	1.64
5:1	0.56	0.60	1.80	2.00	0.68	5.00	1.03	1.60	0.99	14.26	1.58
6:1	0.50	0.80	0.90	2.20	1.00	8.20	0.30	0.50	0.99	15.39	1.71
Total	1.47	2.52	3.61	7.85	2.77	24.30	2.16	6.00	3.96	54.64	—
Mean	0.39	0.63	0.90	1.96	0.69	6.07	0.54	1.50	0.99	—	—

ANALYSIS OF VARIANCE

Variance due to	d.f.	SS.	M.S.	F.	P.
Hosts	8	101.49	12.69	27.00	0.001
Treatments	3	1.83	0.61	1.30	—
Residue	24	11.17	0.47	—	—
Total	35	114.49	—	—	—

L.S.D. = 0.69

plots was significantly higher than the "cotton check" means for July in Giza. (Table III) and even than the cowpea means themselves for June in Sakha (Table II) and for July in Giza (Table III). This peculiar result may be attributed to the nature of cowpea growth being slightly shorter than cotton and thus become partially overshadowed by the taller cotton plants. It may also be further attributed to its capability of creeping through and mingling with the neighbouring cotton branches thus enabling the ovipositing moths to lay on the cotton leaves especially if odour is a main factor in host selection.

(c) Cotton

The "cotton check" means varied from those of cowpea and maize but were not always significantly different from them. Nevertheless, cotton may be regarded third rank among the tested host-plants as far as attraction of the ovipositing moth is concerned.

(d) Maize and Sunflower plants

These two host-plants failed to show any signs of attractiveness to the ovipositing moth. Together with the cotton plants grown in their plots they received

TABLE III

Giza experiment (July 1956). — Daily mean number of egg-masses per row of host-plant.

Treatment	Cotton in maize	Maize	Cotton in cowpea	Cowpea	Cotton in castor	Castor	Cotton check	Total	Mean
3:1	0.13	0.60	1.40	1.60	0.70	1.60	1.33	7.36	1.05
4:1	0.30	0.80	2.30	0.80	0.55	3.80	1.33	9.88	1.41
5:1	0.44	1.00	2.30	1.00	0.60	3.60	1.33	10.27	1.47
6:1	0.66	1.33	1.80	0.40	0.61	3.33	1.33	9.46	1.35
Total	1.53	3.73	7.80	3.80	2.46	12.33	5.32	36.97	—
Mean	0.38	0.93	1.95	0.95	0.61	3.08	1.33	—	—

ANALYSIS OF VARIANCE

Variance due to	d.f.	SS.	M.S.	F.	P.
Hosts	6	20.67	3.45	15.00	0.001
Treatments	3	0.72	0.24	1.00	—
Residue	18	4.10	0.23	—	—
Total	27	25.49	—	—	—

L.S.D. = 0.49

the least number of egg-masses. Their means were even significantly smaller than the "cotton check" means for July in Sakha (Table III). This unusual result gives the impression that these host-plants repel the insect instead of attracting it. The possibility that these plants had reached a stage of maturity less attractive to the ovipositing moth; or the fact that the comparative tallness of these two plants exposes their leaves to the direct and intensive sun-rays all day long that the moths avoid them, by instinct, as ovipositing sites; can hardly explain this abnormal phenomenon.

The effect of host-plant frequencies

Table VII for Giza and Table VIII for Sakha were constructed to compare the effect of the tested frequencies (2:1, 3:1 etc.) of the secondary host-plants on the number of egg-masses laid on the adjacent main crop (cotton). The data used

in this comparison were the means of egg-masses per row of cotton plants grown on each of the different treatments during the 3 months combined. A survey of the means for the Giza experiment (Table VII) indicate that these figures were too close to each others (1.80, 1.97, 1.95, 1.78) that any significant difference can hardly exist. Accordingly no calculation of the analysis of variance was attempted. In the Sakha experiment, however, the means of the different treatments (Table VIII) showed a tendency to increase gradually (1.40, 2.94, 3.06, 3.11) with the decline in the frequency of the host-plant rows (2:1, 3:1, 5:1 and 6:1). The calculated analysis of variance, however, did not lend statistical support to this biological observation (the variance ratio or F. value being non-significant). Thus indicating, in a broad sense, that 6:1 exert the same effect as 2:1.

TABLE IV

*Sakha experiment (July 1956). — Daily mean number
of egg-masses per row of host-plant*

Treatment	Cotton in Sunflower	Sunflower	Cotton in cowpea	Cowpea	Cotton in castor	Castor	Cotton in maize	Maize	Cotton check	Total	Mean
2:1	0.28	0.07	0.71	2.50	4.80	19.57	0.53	0.21	4.82	33.49	3.72
3:1	0.23	0.90	9.30	7.00	7.60	18.00	1.30	1.10	4.82	50.25	5.58
5:1	0.60	1.80	5.60	8.80	8.17	13.70	3.50	1.50	4.82	48.49	5.39
6:1	1.16	0.80	5.06	12.40	10.56	9.80	0.80	0.50	4.82	45.90	5.10
Total	2.27	3.57	20.67	30.70	31.13	61.07	6.13	3.31	19.28	178.13	—
Mean	0.57	0.89	5.17	7.67	7.78	15.27	1.53	0.83	4.82	—	—

ANALYSIS OF VARIANCE

Variance due to	d.f.	SS.	M.S.	F.	P.
Hosts	8	745.23	93.15	14.67	0.001
Treatments	3	19.13	6.38	1.00	—
Residue	24	152.47	6.35	—	—
Total	35	916.83	—	—	—

L.S.D.=2.56

TABLE V

Giza experiment (August 1956). — Daily mean number of egg-masses per row of host-plant

Treatment	Cotton in maize	Maize	Cotton in cowpea	Cowpea	Cotton in castor	Castor	Cotton check	Total	Mean
3:1	0.06	0.20	0.50	0.30	0.30	0.0	0.13	1.49	0.21
4:1	0.30	0.20	0.40	0.0	0.20	0.20	0.13	1.43	0.20
5:1	0.24	0.0	0.36	0.60	0.12	0.0	0.13	1.45	0.21
6:1	0.11	0.50	0.13	0.0	0.03	0.33	0.13	1.23	0.18
Total	0.71	0.90	1.39	0.90	0.65	0.53	0.52	5.60	—
Mean	0.18	0.22	0.35	0.22	0.16	0.13	0.13	—	—

TABLE VI

Sakha experiment (August 1956). — Daily mean number of egg-masses per row of host-plant

Treatment	Cotton in Sunflower	Sunflower	Cotton in cowpea	Cowpea	Cotton in castor	Castor	Cotton in maize	Maize	Cotton check	Total	Mean
2:1	0.85	0.30	2.00	8.71	3.68	10.64	2.40	2.85	4.05	35.48	3.94
3:1	0.70	1.50	8.40	9.70	3.80	27.50	2.30	5.80	4.05	63.75	7.08
5:1	1.30	1.80	7.13	8.00	3.40	11.86	2.97	5.80	4.05	46.31	5.15
6:1	1.83	1.80	5.10	7.80	7.06	9.40	3.00	2.60	4.05	42.64	4.74
Total	4.68	5.40	22.63	34.21	17.94	59.40	10.67	17.05	16.20	188.18	—
Mean	1.17	1.35	5.66	8.55	4.48	14.85	2.67	4.26	4.05	—	—

ANALYSIS OF VARIANCE

Variance due to	d.f.	SS.	M.S.	F.	P.
Hosts	8	579.01	72.38	8.08	0.001
Treatments	3	48.80	16.03	1.79	—
Residue	24	215.01	8.96	—	—
Total	35	842.10	—	—	—

L.S.D. = 6.17

TABLE VII

Giza experiment. — 3-Monthly mean number of Prodenia egg-masses per row of cotton in different frequency treatments

Treatment	Cotton in maize	Cotton in cowpea	Cotton in castor	Total	Mean
3:1	0.16	4.07	1.17	5.40	1.80
4:1	0.38	4.38	1.15	5.91	1.97
5:1	0.37	4.12	1.36	5.85	1.95
6:1	0.58	3.84	0.93	5.35	1.78
Total	1.49	16.41	4.61	22.51	—
Mean	0.37	4.10	1.15	—	—

TABLE VIII

Sakha experiment. — 3-Monthly mean number of Prodenia egg-masses per row of cotton in different frequency treatments

Treatment	Cotton in sunflower	Cotton in cowpea	Cotton in castor	Cotton in maize	Total	Mean
2:1	0.47	0.97	3.04	1.12	5.60	1.40
3:1	0.35	6.13	3.95	1.33	11.76	2.94
5:1	0.82	4.84	4.08	2.50	12.24	3.06
6:1	1.16	3.69	6.21	1.37	12.43	3.11
Total	2.80	15.63	17.28	6.32	42.03	—
Mean	0.70	3.91	4.32	1.58	—	—

ANALYSIS OF VARIANCE

Variance due to	d.f.	S.S.	M.S.	F.	P.
Treatments	3	8.09	2.70	1.81	—
Hosts	3	37.26	12.42	8.34	0.01
Residue	9	13.37	1.49	—	—
Total	15	58.72	—	—	—

SUMMARY

The host preference of the ovipositing cotton leaf worm moth *Prodenia litura* F. was tested in the field. Castor oil plants, cowpea, cotton, maize and sun-flower plants were distributed at various densities in two experimental areas: Giza and Sakha (nearly 100 miles apart). The biological observations and, to a certain extent, the statistical analysis of the data indicated that the above-given sequence of the plants may be their proper arrangement as far as the host-preference is concerned. The castor oil plant presented a working possibility to act as a practical trap-crop for the ovipositing moths in cotton fields but not with the methods of distribution applied in the present investigation. The effect of the comparative density of cotton rows to other host-plants (2:1, 3:1, 4:1, 5:1, and 6:1) on the ratio of oviposition on cotton plants was also tested and the different frequency treatments showed non-significant differences.

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EFFECT OF ADULT POPULATION DENSITY ON THE SILVER Y-MOTH (*PLUSIA GAMMA* L.)

[*Lepidoptera: Noctuidae*]

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INTRODUCTION

Population density is one of the important ecological factors which guides the course of a population. It has been accepted as a major factor controlling the phases in locusts, in both nymphal and adult stages. FAURE (1943 and 1943 a) was the first to show the phase variation in the caterpillars of the Lesser Army Worm (*Laphygma exigua*) and the Army Worm (*Laphygma exempta*) according to their density. LONG (1953), ZAHER and LONG (1959) and LONG and ZAHER (1958 and 1960) showed that crowding larvae of *Plusia gamma* and *Pieris brassicae* affected the biology, morphology and physiology of the larvae and adults.

Previous workers on the insects of stored products and *Drosophila* had agreed that high densities of adults reduced the fecundity of females while the effect of low densities is still debatable. Therefore, an investigation was made to show the effect of low levels of population density of *Plusia gamma* adults on their reproductive capacity and longevity.

METHODS

250 larvae were bred in groups of 50 in two-litre beakers, on agricultural mustard. About 180 reached the pupal stage and from these 170 adults emerged. On emergence, the moths were placed in one of four density levels, these being 1, 2, 4, and 8 pairs per container. The moths were kept in celluloid cylinders 20×25 cm. with a piece of hardboard fixed as a base and with a removable musline top. The

moths were fed with 15% honey solution placed in small petri dishes and covered by fine copper mesh painted with shellac. The experiment was set up over a period of 4 days, each day the adults which emerged were paired and were spread equally between the different densities. The individuals present in each cylinder all emerged on the same day. The moths were distributed so that there were 14 cylinders set up with one pair, 7 cylinders with two pairs, 5 cylinders with four pairs and 3 with eight pairs. One of the principal difficulties which limited the number of replicates that of raising a sufficiently large homogenous stock of larvae due to the limited number of eggs obtained at one time.

RESULTS

Pre-oviposition period

In the case of the single pairs, the minimum time elapsing between emergence and the first egg laid was 5 days and the maximum was 12 with a mean of 7.7 days.

In the other density levels it was impossible to record the preoviposition period of each female present in one cylinder. The mean of the replicates of each density does not represent the actual mean of the individuals, but it does represent the mean of the minimum preoviposition periods. It is not known whether this period for each container obtained from one or more females but it does however represent at least one female.

TABLE I
*The pre-oviposition period up to the first day
of egg-laying in each container*

Density level	Pre-oviposition period in days												Replicate mean in days
	2	3	4	5	6	7	8	9	10	11	12		
	Number of replicates												
One pair.....	—	—	—	1	—	6	5	1	—	—	1	7.7	
Two pairs	—	—	—	2	2	2	—	1	—	—	—	6.4	
Four pairs	—	—	3	1	1	—	—	—	—	—	—	4.6	
Eight pairs.....	1	—	2	—	—	—	—	—	—	—	—	3.3	

Table I shows that at the two pairs density level, the minimum ranged from 5 to 9 days with a mean of 6.4 days. At 4 pairs the mean was 4.6 days with a range of 4 to 6 days. From the highest density level, that of 8 pairs, the shortest minimum period was recorded. The range was from 2 to 4 days and the mean was 3.3. days.

From the results obtained it is apparent that some of the crowded individuals laid before any of the solitary ones, and this shows that at least the first individuals

to lay in each cylinder were affected by the adult density. Although the results were complicated by different numbers of individuals being involved in the different density levels it appears that the higher the density, the shorter the preoviposition period. Assuming that the figure obtained from the preoviposition period for each container was represented by only one female, it would imply that the mean replicate represents only 14, 7, 5 and 3 females for the densities of 1, 2, 4 and 8 pairs respectively. This would imply that whilst all the females used were considered for the single pair density, only 50% was used for the 2 pairs, 25% for the 4 pairs and 12.5% for the 8 pair density level.

It is therefore reasonable to consider only the preoviposition period for the first 12.5% of the observations of the single pairs and to compare them with the mean replicate obtained from the 8 pairs density. The same principle was employed in the case of 2 and 4 pairs by comparing their mean replicates with the preoviposition period of the first 50% and 25% of the single pair observations respectively, as shown in Table II.

TABLE II
Pre-oviposition period in days

Means	2 pairs	4 pairs	8 pairs
Replicate mean	6.4	4.6	3.3
Corrected mean for the single pairs	6.7	6.5	6.0

Thus by using this method for computing the preoviposition period, certain females of different population densities still show that their periods were shorter than that of the corrected means of the single pairs.

Number of eggs laid per female

The number of eggs laid per female increased with the density over the range examined. Figure 1 shows that under the conditions of the experiment, the relationship between the number of eggs per female and the density is not a simple arithmetic one, nor linear for the geometric series used. A large increase in the number of eggs over those from the single pairs occurred in the case of the two-pairs density level, while the additional increases at the four- and eight-pairs density levels were not significant.

Longevity

The mean longevity of the females differed with the different density levels; at one pair density level, it was 22.6 days while at the 8 pairs density level it was

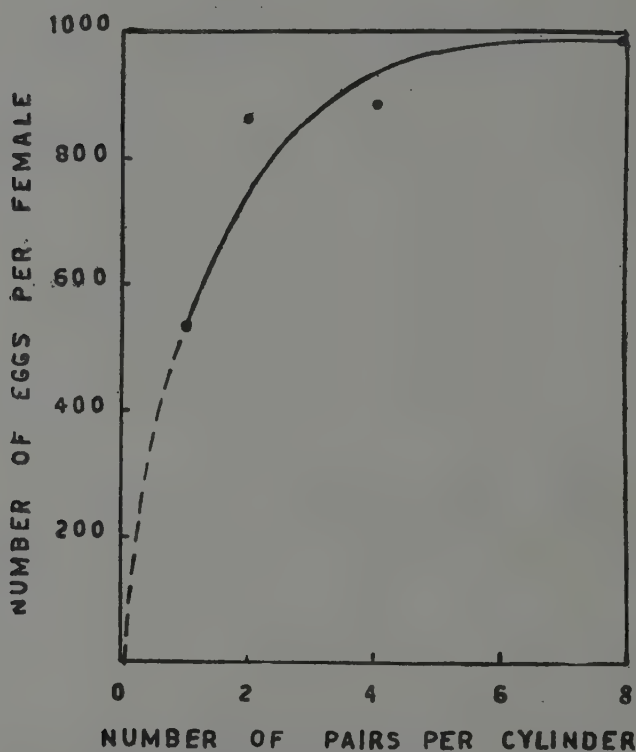


FIG. 1: Effect of the number of moths per cage on the total number of eggs laid per female.

18,5 days, showing the occurrence of a negative relationship with the population density (Table III).

TABLE III

Mean longevity of moths at different density levels.

Density level		1 pair	2 pairs	3 pairs	4 pairs
Mean longevity in days . .	Female	22.6	20.1	17.9	18.5
» » »	Male	18.2	16.5	16.2	19.7

On the other hand, the effect of density on the male longevity was obscure, as shown in Table III, and implies further investigation.

DISCUSSION

The results showed that the rate of sexual maturation of the female was proportional to the density level, the higher the density the more rapidly the females mature. However by considering the minimum preoviposition period, it was found that this period decreased with the increasing density. The minimum preoviposition period for females of 1 pair density level is more than double the period at 8 pairs. Adults of densities of more than one pair were always active and were observed to be flying most of the time, as when one flew it stimulated the others to fly. So this rapid maturation with the increasing density could be due to higher activity resulting from mutual stimulation, but this needs experimental confirmation. From the finding of NORRIS (1954) on the Desert Locust *Schistocerca gregaria* another suggestion would be that one early matured moth would accelerate the maturation of the immature individuals and injury caused by damage to legs or antennae resulting from their greater flight activity, would induce rapid maturation. This latter phenomenon was found with crowded adults.

The number of eggs produced by the female increased with the increasing density. Here again it might be assumed that activity was the most effective factor in inducing this high egg production. BODENHEIMER (1944) and JOHNSON (1955) found that the maturation flight was necessary for maximum reproduction in the Locust *Dociostaurus maroccanus* and the aphid *Aphis fabae*. This phenomenon appeared very clearly in the case of the two pairs density level, while in the other densities the additional increases were not so great. This suggests that at the higher density levels the effect of contact between individuals, in stimulating egg laying, was approaching its maximum.

The length of life of females decreased with the increasing density. This might be expected, as it bore a negative relationship with maturation period and rate of egg production.

Thus it could be concluded that in *P. gamma*, an increase of population density in the lower density levels accelerated the rate of maturation, increased the number of eggs and shortened the longevity of the females.

SUMMARY

Pairs of freshly emerged moths of *Plusia gamma* were set up at population densities of 1, 2, 4 and 8 pairs per cage.

Increasing population density was found to reduce the pre-oviposition period of certain individuals.

The fecundity was also increased; nearly twice the number of eggs per female being laid in the 8 pair density level. Most of this increase was obtained with an increase in the population density from 1 to 2 pairs per cage.

The longevity of females was found to decrease with increasing population density.

ACKNOWLEDGMENT

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ABUNDANCE OF THE COTTON LEAF WORM, *PRODENIA LITURA* (F.), IN RELATION TO HOST PLANTS

I. HOST PLANTS AND THEIR EFFECT ON BIOLOGY

[*Lepidoptera: Agrotidae - Zenobiinae*]

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and FAWKIA KOTBY⁽³⁾

INTRODUCTION

Food plants have been known to play an important role in the ecology of many species especially with regard to distribution and abundance. ISLEY (1938) and PFADT (1949) recognized the significance of plant species as food in relation to distribution of grasshoppers. Also effects of various food plants on different insects have been demonstrated by SEAMANS and McMILLAN (1935), BASU (1944), SMITH, HANDFORD and CHEFURKA (1952), DAVEY (1954) and others.

In Egypt, the cotton leaf worm (*Prodenia litura*) is a well known polyphagous species where it attacks field, forage, and truck crops as well as ornamentals. Yet, no previous attempts were made to investigate the relationship between abundance of this pest and its hosts. Thus, the purpose of this paper is to review the host plants of this pest according to preferred hosts for feeding and oviposition, their range of distribution and systematic position. It also presents a preliminary study on effects of some host plants on the development and reproductive capacity of this species.

Investigations reported herein were carried out at the laboratory of Plant Protection Department of Ministry of Agriculture, Cairo, during the summer, 1958.

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(A) HOST PLANTS

The range and abundance of the cotton leaf worm is limited by the range and abundance of its hosts. This pest is found established in many parts of tropical and temperate zones of the Old World where it attacks a wide variety of plants amounting to approximately 112 species. These host plants belong to diverse systematic groups comprising 44 families (Table I). Only eight families include over 50 per cent of the plants infested by this pest and are arranged in a decreasing order as follows: Leguminosae, Solanaceae, Malvaceae, Moraceae, Compositae, Gramineae, Chenopodiaceae and Cruciferae.

TABLE I

Host plants of the cotton leaf worm

Host	Family	Distribution
I. Hosts preferred for oviposition		
Casuarina (<i>Casuarina equisetifolia</i> L.)	Casuarinaceae	Egypt
Changeable rose (<i>Hibiscus mutabilis</i> L.)	Malvaceae	Egypt
Cocoa-nut palm (<i>Cocos nucifera</i> L.)	Palmae	Fiji
Common fig tree (<i>Ficus carica</i> L.)	Moraceae	Egypt
Common orange tree (<i>Citrus aurantium</i> L.)	Rutaceae	Egypt
		Fiji
		Palestine
		Sierra Leone
Cowpea (<i>Vigna sinensis</i> Endl.)	Leguminosae	Egypt
		Malaya
Date-palm (<i>Phoenix dactylifera</i> L.)	Palmae	Egypt
Deccan hemp (<i>Hibiscus cannabinus</i> L.)	Malvaceae	Egypt
<i>Ficus infectoria</i> L.	Moraceae	India
<i>Ficus</i> spp.	Moraceae	Egypt
Flowering reed (<i>Canna indica</i> L.)	Cannaceae	Fiji
Grape vine (<i>Vitis vinifera</i> L.)	Vitaceae	Egypt
		Palestine
Guava tree (<i>Psidium guajava</i> L.)	Myrtaceae	Egypt
Gum arabic tree (<i>Acacia arabica</i> Willd.)	Leguminosae	Egypt
Hollyhock (<i>Althaea rosa</i> Tourn.)	Malvaceae	Egypt
Jute plant (<i>Corchorus capilaris</i> L.)	Tiliaceae	Egypt
		India
Mulberry (<i>Morus</i> sp.)	Moraceae	Egypt
		China
		Formosa
		India
Sesban (<i>Sesbania aculeata</i> Poir.)	Leguminosae	India
Sissoo tree (<i>Dalbergia sissoo</i> Roxb.)	Leguminosae	Egypt
Sycamore-fig tree (<i>Ficus variegata</i> Blume)	Moraceae	Egypt

TABLE I (continued)

Host	Family	Distribution
II. Hosts preferred for food		
African millet (<i>Eleusine caracana</i> Gaertn.)	Gramineae	India
<i>Amaranthus graecizans</i> L.	Amarantaceae	Egypt
Apple of sodom (<i>Solanum sodomaeum</i> L.)	Solanaceae	Egypt
Apple tree (<i>Pyrus malus</i> L.)	Rosaceae	India
Arbor vitae (<i>Thuja orientalis</i> L.)	Coniferae	India
<i>Artocarpus integrifolia</i> L.	Moraceae	India
Aster (<i>Callistephus chinensis</i> Nees)	Compositae	Egypt
Banana (<i>Musa paradisiaca</i> L.)	Musaceae	Egypt
		Australia
		Ceylon
		Fiji
		Hawaii
		India
Bindweed (<i>Convolvulus</i> sp.)	Convolvulaceae	Egypt
Blue clitoria (<i>Clitoria ternatea</i> L.)	Leguminosae	India
Broad bean (<i>Vicia faba</i> L.)	Leguminosae	Egypt
Cacao tree (<i>Theobroma cacao</i> L.)	Sterculiaceae	Nigeria
<i>Carissa edulis</i> Vahl.	Apocynaceae	India
Cassava (<i>Manihot utilissima</i> Pohl.)	Euphorbiaceae	Indo-China
<i>Chrysanthemum indicum</i> L.	Compositae	Egypt
Citron (<i>Citrus medica</i> L.)	Rutaceae	India
Coffee tree (<i>Coffea arabica</i> L.)	Rubiaceae	Kenya
Colocasia (<i>Arum colocasia</i> L.)	Araceae	Egypt
		China
		Fiji
		Guam
		New Guinea
		Samoa
Common mallow (<i>Malva sylvestris</i> L.)	Malvaceae	Egypt
Common mint (<i>Mentha sativa</i> L.)	Labiatae	Egypt
Common potato (<i>Solanum tuberosum</i> L.)	Solanaceae	Egypt
		Cyprus
		Dutch E. Indies
		India
		Palestine
Common wheat (<i>Triticum vulgare</i> Vill.)	Gramineae	Egypt
		Saudi Arabia
Custard apple (<i>Anona squamosa</i> L.)	Anonaceae	India
Eggplant (<i>Solanum melongena</i> L.)	Solanaceae	Egypt
Egyptian clover or berseem (<i>Trifolium alexandrinum</i> L.)	Leguminosae	Egypt
		Algeria
		India
		Palestine

TABLE I (continued)

Host	Family	Distribution
<i>Eucalyptus</i> (<i>Eucalyptus globulus</i> Labill.)	Myrtaceae	Egypt
<i>Eugenia malaccensis</i> L.	Myrtaceae	India
<i>Euphorbia prunifolia</i>	Euphorbiaceae	Egypt
Feather asparagus (<i>Asparagus plumosus</i> Bak.)	Liliaceae	Fiji
Fenugreek (<i>Trigonella foenugraecum</i> L.)	Leguminosae	Egypt
Garden spinach (<i>Spinacia oleracea</i> L.)	Chenopodiaceae	Egypt
		India
Indigo plant (<i>Indigofera tinctoria</i> L.)	Leguminosae	Egypt
		Ceylon
		India
Jew's mallow (<i>Corchorus olitorius</i> L.)	Tiliaceae	Egypt
		India
Leaf-beet (<i>Beta vulgaris foliosa</i> A.Sf.)	Chenopodiaceae	Egypt
Lettuce (<i>Lactuca sativa</i> L.)	Compositae	Egypt
		Fiji
Lucerne (<i>Medicago sativa</i> L.)	Leguminosae	Egypt
		Australia
		India
		Saudi Arabia
		Spain
Mandarine orange (<i>Citrus aurantium deliciosa</i> L.)	Rutaceae	Egypt
Mango tree (<i>Mangifera indica</i> L.)	Anacardiaceae	India
<i>Moringa pterygosperma</i> Gaertn.	Dipsacaceae	India
Night-jasmine (<i>Cestrum nocturnum</i> L.)	Solanaceae	India
Onion (<i>Allium cepa</i> L.)	Liliaceae	Egypt
		China
		Dutch E. Indies
Papaya (<i>Carica papaya</i> L.)	Caricaceae	India
Pigeon-pea (<i>Cajanus indicus</i> Spreng.)	Leguminosae	India
Plum tree (<i>Prunus domestica</i> L.)	Rosaceae	Egypt
Pomegranate (<i>Punica granatum</i> L.)	Punicaceae	Egypt
Poppy (<i>Papaver somniferum</i> L.)	Papaveraceae	Formosa
Prickly lettuce (<i>Lactuca scariola</i> L.)	Compositae	India
Prickly pear (<i>Cactus opuntia</i> L.)	Cactaceae	Egypt
Purslane (<i>Portulaca oleracea</i> D.C.)	Portulacaceae	Egypt
<i>Pyrus sinensis</i> L.	Rosaceae	India
Radish (<i>Raphanus sativus</i> L.)	Cruciferae	China
		India
Red pepper (<i>Capsicum annum</i> L.)	Solanaceae	Egypt
Rice plant (<i>Oryza sativa</i> L.)	Gramineae	Egypt
		Formosa
		Hawaii
		India
		Philippine
Rose (<i>Rosa</i> sp.)	Rosaceae	Egypt

TABLE I (continued)

Host	Family	Distribution
<i>Sesbania aegyptiaca</i> L.	Leguminosae	Fiji
Small flowered mallow (<i>Malva parviflora</i>)	Malvaceae	Egypt
Soya bean (<i>Glycine max</i> L.)	Leguminosae	Egypt
Sugar beet (<i>Beta</i> sp.)	Chenopodiaceae	Dutch E. Indies
		Egypt
		China
		Fiji
		India
		Italian Somalia
		Korea
Sugar cane (<i>Saccharum officinarum</i> L.)	Gramineae	India
Sweet william (<i>Dianthus barbatus</i> L.)	Caryophyllaceae	Egypt
Tea plant (<i>Thea sinensis</i> L.)	Theaceae	Belgian Congo
		Ceylon
		India
		Turkestan
Tobacco (<i>Nicotiana tabacum</i> L.)	Solanaceae	Egypt
		Australia
		Ceylon
		Dutch E. Indies
		Fiji
		Formosa
		India
		Indo-China
		Japan
		Kamerun
		Malaya
		Mauritius
		New Caledonia
		Nigeria
		Nyassaland
		Philippine
		Rhodesia
		Tanganyika
Tomato (<i>Solanum lycopersium</i> L.)	Solanaceae	Egypt
		Ceylon
		Fiji
		Japan
		Philippine
		Samoa
Turnip (<i>Brassica rapa</i> L.)	Cruciferae	Egypt
Turnip rooted celery (<i>Opium graveolens</i> C.)	Umbelliferae	India
Wall goose-foot (<i>Chenopodium murale</i> L.)	Chenopodiaceae	Egypt
Water melon (<i>Citrullus vulgaris</i> Schrad.)	Cucurbitaceae	Egypt

TABLE I (continued)

Host	Family	Distribution
White datura (<i>Datura</i> sp.)	Solanaceae	<i>Egypt</i> Philippine
Violet (<i>Viola odorata</i> L.)	Violaceae	<i>Egypt</i> India
Zinnia (<i>Zinnia elegans</i> Jacq.)	Compositae	<i>Egypt</i>
III. Hosts preferred for both food and oviposition		
Brussels sprout (<i>Brassica oleracea gemmifera</i> L.)	Cruciferae	<i>Egypt</i>
Cabbage (<i>Brassica oleracea capitata</i> L.)	Cruciferae	<i>Egypt</i> Australia Fiji India Italian Somalia Philippine Uganda
Castor oil plant (<i>Ricinus communis</i> L.)	Euphorbiaceae	<i>Egypt</i> Burma Ceylon China Formosa India Indo-China Malaya Philippine
Cauliflower (<i>Brassica oleracea</i> L.)	Cruciferae	<i>Egypt</i> Dutch E. Indies India
<i>Cineraria hybrida</i> L.	Compositae	Nyassaland
Cotton (<i>Gossypium barbadense</i> L.)	Malvaceae	<i>Egypt</i> <i>Egypt</i> Algeria Australia Belgian Congo Burma Ceylon French Equatorial Africa Gambia Guinea Nigeria Nyassaland Philippine Somaliland Tanganyika U. S. Africa

TABLE I (continued)

Host	Family	Distribution
French bean (<i>Phaseolus vulgaris</i> L.)	Leguminosae	Egypt Ceylon India Italian Somalia Mesopotamia Nyassaland Uganda
Maize (<i>Zea mays</i> L.)	Gramineae	Egypt Australia Fiji India Nigeria Nyassaland Philippine Saudi Arabia
Okra (<i>Hibiscus esculentus</i> L.)	Malvaceae	Egypt
Pea nut (<i>Arachis hypogaea</i> L.)	Leguminosae	Egypt India Italian Somalia Madagascar Nyassaland Phillipine Uganda
Sweet potato (<i>Ipomoea batatas</i> Poir.)	Convolvulaceae	Egypt Dutch E. Indies Formosa Nyassaland Philippine
White poplar (<i>Populus alba</i> L.)	Amentaceae	Egypt

IV. Hosts with preference unknown

Carrot (<i>Daucus carota sativa</i> L.)	Umbelliferae	China Fiji
Common pea (<i>Pisum sativum</i> L.)	Leguminosae	India
Gero-corn (<i>Penicillaria spicata</i> Willd.)	Gramineae	India
Lantana (<i>Lantana salvifolia</i> L.)	Verbenaceae	Australia
Oxalis (<i>Oxalis crenata</i> Jacq.)	Oxalidaceae	Ceylon
Sacred fig tree (<i>Ficus religiosa</i> L.)	Moraceae	India
Shallots (<i>Allium ascalonicum</i> L.)	Liliaceae	Dutch E. Indies.
Snake weed (<i>Polygonum glabrum</i> L.)	Polygonaceae	India
Sorrel (<i>Rumex sesicarius</i> L.)	Polygonaceae	India
Sun-flower (<i>Helianthus annuus</i> L.)	Compositae	Tanganyika Union South Africa

Informations gathered from the literature showed that host plants are not equally preferred by the cotton leaf worm. While 20 plants are selected by the moth for oviposition, 70 plant species are attacked by the larvae for food. However, 12 hosts are recorded to serve for both oviposition and food sites (Table I).

In Egypt, 73 host plants are recorded to be attacked by the cotton leaf worm. Most of these plants were previously listed by BISHARA (1934) and WILLCOCKS and BAHGAT (1937) while four new ones are reported by the authors. These new hosts include: lettuce as food, Sissoo and Casuarine trees for oviposition and *Cineraria hybrida* for both oviposition and food. In general, it was found that this pest readily feeds on 45 plants, deposits its egg-masses on 16 different hosts, while other 12 plants are preferred for both food and oviposition. However, hosts of economic importance upon which it is most injurious are cotton, berseem and corn.

Such knowledge of host plants and their range of distribution will be helpful in checking the possible spread of this pest.

(B) EFFECT OF HOST PLANTS ON BIOLOGY

Materials and methods

Eight host plants were used in this investigation namely: berseem, cotton, corn, okra, grape vine, castor oil plant, cabbage and cowpea. Choice of hosts was based on the fact that the first three hosts are heavily attacked in fields while the other five are preferred for oviposition.

For this purpose larvae were obtained from two mixed batches of eggs collected from neighbouring fields. Larvae were transferred to hosts immediately after hatching. Only leaves of about same age of the different hosts were used as food for larvae. Four replicates of fifty larvae each were set for every host. Leaf petioles were mounted through a hole in a cork fitted to a 2×1" specimen tube filled with water and put in a one litre beaker. Before mounting petioles, a 5.5 cm. filter paper collar was fitted around them and secured in place by cotton wool. This helped confine young larvae to host and prevented them from drowning. Few sticks were put in each beaker to enable fallen larvae to climb back to their food. Beakers were then covered with muslin and secured at top with rubber bands. However, it was made sure that larvae received an adequate supply of fresh food every day. All beakers were kept under identical conditions of moisture and temperature in the laboratory.

Just before pupation coarse saw dust was put in each beaker to provide a suitable site for pupation. Beakers were daily examined for newly formed pupae which were removed, weighed and kept in individual tin boxes until adults emerged.

Freshly emerged moths of each treatment were sexed and grouped in pairs of same age. Each pair was put in a glass jar and fed on 20% fresh honey solution.

A fresh green leaf was placed in the jar to provide site for oviposition. Rearing was continued until oviposition ceased and adults died.

RESULTS AND DISCUSSION

Effect of host on larval duration

Host plants have variable effects on development of larvae of the cotton leaf worm. Larvae reared on leaves of corn and grape vine surrendered a heavy mortality rate. The shortest period of larval stage (about 12.8 days) was obtained from larvae fed upon leaves of castor oil plant and berseem (Table II). On the contrary, the longest period for larval development (16.8 days) resulted when larvae were offered cotton leaves. However, the average durations of larval stage ranged from 14.2 days on okra to 15 days on cowpea to 15.4 days on cabbage. These results agree with the findings of BASU (1944) in which larval duration was shorter in the cabbage treatment than in the cotton one.

Effect of host on pupal weight

Weights of newly formed pupae were influenced by larval food. The heaviest pupae (198 mg.) were obtained from larvae fed on okra while those fed on cowpea produced the lightest pupae (115 mg.). From the results obtained, host plants may be arranged in an ascending order with respect to pupal weight as follows: cowpea, cabbage, berseem, cotton, castor oil plant and okra. Variation in pupal weights due to larval food was found to be highly significant.

Effect of host on pupal duration

Subsequent effects of host plants have been manifested on pupal development. The shortest duration was 6.5 days for pupae obtained from larvae fed on okra (Table II). The castor oil plant and berseem had equal effects on pupal duration which lasted for 6.7 days in both treatments. In the case of larvae fed on cotton and cowpea the pupal duration reached 7.2 and 7.7 days respectively. Analysis of variance showed that differences in pupal durations among treatments were highly significant. However, it may be noticed that there is a negative relationship between the weight and duration of pupal stage. This phenomenon was also observed when examining data given by BASU (1944).

It is worth noting that owing to the spread of virus disease in the cabbage treatment, no records of pupal periods were available.

Effect of host on longevity of moths

Longevity of moths of the cotton leaf worm is also affected by larval food. Moths ensued from larvae fed on okra and castor oil plant had the longest life

span as the mean longevity obtained for the former reached 8 days and 7.2 days for the latter (Table II). The shortest periods of longevity of moths were those obtained from cotton (6.2 days) and berseem (6.6 days) treatments.

Effect of host on reproductive capacity

Larval food has a marked effect on number of eggs laid by moths. Although the number of females used did not exceed twenty in each treatment, yet the data obtained showed the general trend. Moths produced from larvae fed on okra laid the highest number of eggs (706 eggs per female). The mean number of eggs per female moths ranged from 333 to 494 eggs in all other treatments of berseem, castor oil plant and cotton (Table II).

TABLE II

Effect of host plants on biology of the cotton leaf worm

Host plant	Larval period mean days	Pupal weight mean mg.	Pupal period mean days	Moth longevity mean days	Ovi-rate mean number
Berseem	12.9±0.01	136±1.1	6.7±0.01	6.6±0.6	366±2
Cabbage	15.4±0.26	130±1.7	—	—	—
Castor oil plant	12.8±0.01	171±0.3	6.7±0.01	7.2±0.1	333±4
Corn (*)	—	—	—	—	—
Cotton	16.8±0.06	148±1.8	7.2±0.05	6.2±0.8	494±4
Cowpea	15.0±0.11	115±1.4	7.7±0.15	— ⁽¹⁾	—
Grape vine (*)	—	—	—	—	—
Okra	14.2±0.01	198±0.4	6.5±0.01	8.0±0.1	706±4

(*) Young larvae failed to survive.

(1) Most moths died during first 3 days after emergence.

SUMMARY

Approximately 112 plant species belonging to 44 families are reported as hosts of the cotton leaf worm in tropical and temperate zones of the Old World. These plants include 73 species recorded from Egypt of which 16 hosts are preferred for oviposition, 45 for food only, and 12 for food and oviposition.

Investigations were also undertaken in the laboratory to determine effects of host plants on the biology of the cotton leaf worm. Host plants showed variable effects on development and reproductive capacity of this pest. Berseem was found to shorten the life cycle while cotton prolonged it. Okra favoured larvae to produce

moths of high egg potential. On the other hand, first instar larvae failed to survive on grape vine and corn.

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FACTORS AFFECTING THE INITIATION OF DIAPAUSE IN THE PINK BOLLWORM, *PECTINOPHORA GOSSYPIELLA* SAUNDERS

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INTRODUCTION

The factors affecting the onset of diapause in insects have been widely investigated. Temperature, humidity, food, age, maternal characters, rhythm and illumination are considered to be the most important factors in this respect.

It is commonly believed by workers on the pink bollworm *Pectinophora gossypiella* S. that the initiation of diapause in this pest is related to one or more of the following factors: temperature, relative humidity (or moisture), food and rhythm. GOUGH (1916), WILLCOCKS (1916), BALLOU (1920), BALLARD (1921) and LOFTIN, MCKINNEY and HANSON (1921) considered temperature as the sole effective factor in the induction of diapause in the pink bollworm. SQUIRE (1937 and 1940) relied much on the effect of food. Combination of temperature and food was thought to be important by BISHARA (1930), BEDFORD (1934) and FIFE (1949), while WILLIAMS (1924) and TAYLOR (1936) stated that, in addition to the previous two factors, humidity and rhythm are affective too. WOLCOTT and SEIN (1931) observed no resting larvae during the rainy season, while they develop in the dry period of the year. Other authors, like STOREY (1921), JOHNSTON (1929) and BREDO (1934), did not propose any definite factor. However, they did not discuss the relative importance of these factors.

The application of external factors such as chilling, mechanical stimuli, exposure to short waves and electric shocks, has never been worked out on insects for the induction of the diapause stage. However, these stimuli have been widely used for the breakdown of the quiescent stage in many insects. In case of the pink bollworm, it was thought by the authors that incidence of diapause might be due to the presence of "internal factor or factors" which are secreted at a time before

the onset of diapause. Hence, the application of such external stimuli might destroy these factors and the normal short-cycle of the insect is continued. Similar assumptions were put forward by BAUMBERGER (1917), BODINE (1932 a and b) and DITMAN, WEILAND and GUILL (1940). BAUMBERGER concluded that organisms with periodic diapause prepare for it at a certain time regardless of the temperature, food or relative humidity that attain at the time of hibernation. These factors are not sufficient to overcome the "tendency" of the insect to hibernate. BODINE, in studying the diapause in the eggs of *Melanoplus differentialis*, advanced a theory that there is a diapause factor, "X-factor", present in the diapause-type eggs of that species at the time they are laid. If the newly laid eggs are held at a comparatively high temperature, the potency of the diapause factor increases until it passes a threshold at the "three weeks" stage and stops embryonic development. This factor is gradually dissipated after this point and eventually allows development to resume though in long periods. However, exposure to low temperatures at any time, either before or after the "three weeks" stage, rapidly destroys the diapause factor and development is resumed in comparatively short periods, as soon as the temperature is increased. DITMAN, WEILAND and GUILL (1940), experimenting with the corn earworm, *Heliothis armigera*, concluded that the pupal diapause is caused by low temperatures during the larval period and that neither the water content of the pupae nor the age of the corn on which the larvae are fed appear to exert any influence on the tendency of the pupae to enter the diapause.

In the present work it was thought enlightening to breed the fourth stage active larvae in a wide range of temperature and relative humidity and at different times of boll formation during the cotton season. In this way the three factors (temperature, relative humidity and food) are arranged according to their relative importance in diapause induction. In addition, some external stimuli are applied to the mature active larvae at two intervals in the year; one during the cotton season (September) when the prevailing conditions of temperature and food are mostly favourable for the production of short-cycle forms of larvae, and the other at the end of the year (December), when these factors are lacking and the general trend of most of the larvae is towards diapause. Any deviation from these normal trends would thus be due to the effect of the stimulus used. If the percentage of the active larvae that enter the resting stage at September is increased, then the stimulus used helps the initiation of diapause. On the other hand, if the percentage of the active larvae that pupate at December is increased, then the stimulus used inhibits the onset of diapause.

OBSERVATIONS ON THE INCIDENCE OF DIAPAUSE

1. Temperature and relative humidity

During the course of this work temperature and relative humidity of the room were registered weekly by a recording thermo-hygrograph.

2. Seasonal occurrence of the resting stage

This is a comparative study of the incidence of diapause in the pink bollworm in the different months of the year and from different host plants.

Experiment

Mature active larvae were collected from cotton bolls in two months of the cotton season, September and October, and from green pods of *bamia* (*Hibiscus esculentus*) in December. Each ten larvae were introduced in a specimen tube of dimensions $7 \times 1\frac{1}{2}$ cm., with fragments of cotton fibres to avoid cannibalism and to aid the larvae in the construction of their cocoons. The mouth of the tube was covered by muslin held in position by rubber band. Tubes were then left under the natural conditions of the laboratory.

In order to distinguish between the long-cycle larvae of the pink bollworm and the short-cycle ones, FIFE (1949) was the first to put reasonable and ascertainable limits between these two phases. He noted that the rate of pupation of the active fourth stage larvae was greatest in the first ten days, whereas, after 20 days there was almost no pupation. He stated that "although no definite period can be established, it would seem logical to classify larvae as of the resting type if they do not pupate within 20-30 days after reaching maturity". In this work, a thirty-days period was taken constantly as a limit between long- and short-cycle forms; the larvae remaining alive at the end of this period were safely considered as resting larvae. Thereby, the percentage of larvae that died, pupated or entered the resting stage were estimated. In addition, the ratio of the living larvae (resting) to the total living larvae and pupae (expressed in this work as R/TL) at the end of the thirty days period was also calculated. This ratio gives an accurate picture of the percentage of resting larvae after excluding mortality.

Results

It was clear that mortality in all months did not exceed 10%. The percentage of R/TL increased greatly towards the end of the year, irrespective of the type of food, being 29.1, 61 and 100% in September, October and December, respectively.

The average temperature and relative humidity prevailing during the period between 2nd September and 2nd October, 1957, were 27.1°C and 51.2% R.H., and that from 2nd October to 1st November, 1957, were 26.3°C and 52.2% R.H. As clear there was hardly any change in the weather conditions at both months, however the percentage of resting larvae had increased much. The only difference was however in the composition of the cotton bolls which are known to become much drier and richer in oil content towards the end of the season. Temperature and relative humidity in the period between 6th December, 1957, and 5th January, 1958, were 18°C. and 50% R.H. on the average. Percentage of moisture and oil content of *bamia* seeds were on the average 67.5 and 8.64%, respectively, however, the percentage of R/TL reached 100%. This controversy will be better explained

in the following chapter, dealing with the relative importance of temperature and food in inducing the diapause stage.

It can be concluded that, under the natural conditions of the laboratory, the percentage of larvae that enter the resting stage increases gradually towards the end of the cotton season. At the same time, higher percentages are still observed at the end of the year, irrespective of the type of food.

3. Relationship between average body weight and percentage of larvae that enter the resting stage

This experiment was carried out to estimate the relationship between the larval size (or in other words the state of growth, whether full-grown, half-grown or just early in that stage) and percentage of larvae that enter the diapause stage, provided that the prevailing temperature is suitable for the onset of the resting stage.

Experiment

Active fourth stage larvae were brought in December 29th, 1956, when the temperature of the environment was around 14°C., and were differentiated into three main sizes; abnormally large size (full-grown, average weight 35.4 ± 1.14 mg.), abnormally small size (at the beginning of the instar, average weight 19.3 ± 1.27 mg.) and a medium size (half-grown, average weight 28.2 ± 1.17 mg.). Larvae of the two extreme sizes were comparatively rare in each collection. Determinations of the average body weight were calculated from weighings of at least thirty single larvae of each size, 180 larvae of each size were collected, put in specimen tubes and left under the room conditions. After thirty days, the percentages of mortality, pupation and resting larvae for each size were determined.

Results

Percentages of the ratio R/TL were similar for the three larval sizes, being 100, 100 and 99.3% for the large, middle and small sizes, respectively. The percentage of mortality, however, was much higher in the small-sized larvae than in any other size.

It appears, therefore, that the average body weight of the larvae has no effect on the percentage of larvae that enter diapause, provided the temperature is suitable for the initiation of that stage.

THE EFFECT OF DIFFERENT TEMPERATURES AND RELATIVE HUMIDITIES ON ACTIVE LARVAE CONSUMING FOOD OF DIFFERENT COMPOSITION

Experiment

Fullgrown active larvae were collected from young, green and fleshy cotton bolls at 21st August, 1956. Larvae were selected from bolls of nearly the same size,

to avoid variation in the moisture and oil contents of the food as far as possible. These were subjected in the same day to four different temperatures of 34, 27, 20 and 13°C. With each of these temperatures, four relative humidities were combined, namely 20, 40, 60 and 90%. The latter were achieved by solutions of KOH. Fifty larvae were used for each combination of temperature and relative humidity.

The rate of mortality and pupation were checked periodically every three days during a period of thirty days. At the end of the latter period, the percentages of mortality, pupation, resting and that of the ratio R/TL at the different temperatures and R.H. were compared with each other.

The same experiment was repeated near the maturation of the bolls (at 29th September, 1956). Active larvae were collected from semi-dry cotton bolls.

At both dates of experiment (21st August and 29th September) the moisture content of the cotton seeds was determined by a drying oven at 110°C and the oil content by a micro-Soxhlet apparatus. Extraction in the latter was carried out by anhydrous ethyl-ether.

Results

It was clear that the moisture content had declined from 61.77 to 36.47% on the average towards the end of the cotton season, while the average oil content had increased from 16.32 to 24.23%.

In August, the percentage of dead larvae at 34°C. was comparatively high at the low relative humidities, being 18, 12, 4 and 2% at 20, 40, 60 and 90% R.H., respectively. At each of the other temperatures of 27, 20 or 13°C., mortality was more or less the same at all humidities, being on the average 5, 3 and 2% at the three temperatures, respectively. The percentage of pupae at the end of the thirty days period was not greatly affected by changing the R.H. within one temperature; differences were small and irregular. The high value of pupae at 90% R.H. combined with 34°C. was mainly due to the increased percentage of mortality at lower humidities. On the other hand, the percentage of pupae increased steadily and very rapidly with the increase in temperature from 13 to 27°C, being on the average 1.44 and 89% at 13, 20 and 27°C., respectively. At 34°C. no further increase was observed and the total average was 85%.

The percentage of the larvae that entered the resting stage and that of the ratio R/TL were also not affected by changes in the relative humidity within the same temperature; differences were negligible. On the contrary, a sharp drop in the average values of both of these items took place with the increase of temperature from 13 to 27°C, being 97 and 98.9% at 13°C., 53 and 54.8% at 20°C. and 6 and 6.4% at 27°C., respectively. By raising the temperature to 34°C. no increased effect was observed and the averages were 6 and 6.45%, respectively.

Results obtained at September showed again that changes in the R.H. within one temperature had mostly negligible effects on the percentages of mortality, pupation and resting larvae as well as on the ratio R/TL. On the other hand, changes in temperature had a pronounced effect on the percentage of larvae that entered

the resting stage. The latter decreased steadily with the increase in temperature, even with the stepping up of temperature from 27 to 34°C. However, the difference in the average values of R/TL between 13 and 20°C. was comparatively lower than those between the other temperatures.

As to the rate of pupation of the larvae it was observed that the number of pupae resulting at each date of observation at one temperature was mostly similar under the four R.H. used, so it was preferred to calculate the percentage of the total number of pupae for all the R.H. at the same date. At high temperatures the rate of pupation increased continuously during the thirty days period and as temperature was lowered it decreased considerably, especially in the last few days where it followed a more or less horizontal course. This case was much more pronounced at September than at August. The only exception was that at August where the rate of pupation was nearly similar at 34 and 27°C. At the same time the difference in the rate of pupation between both seasons was greatest at 27°C., less at 20°C. and lowest at 34°C. At 13°C. hardly any pupation took place at both seasons.

Discussion

The high percentage of mortality observed at high temperatures combined with low relative humidities is mainly due to dessication, otherwise variations in temperatures, relative humidity or even the food seem to have little effect on mortality.

That the percentage of pupae had decreased and that of the larvae that entered the resting stage had increased at both seasons with the decrease in temperature, clearly show that temperature is an important factor governing the initiation of diapause in the pink bollworm. This was also demonstrated by analysing the curves of the rate of pupation of the active larvae, where at high temperatures and at both seasons, the amount of pupae was gradually increasing during the thirty days period indicating much favourable conditions for pupation. At low temperatures, these curves followed a horizontal course in the last days indicating a greater tendency for entering the resting stage.

Relative humidity seems to have negligible effects on the initiation of the resting stage and this was shown by the small and irregular fluctuations caused by varying the humidity within one temperature and by the consistency of the results at both seasons.

Food plays an important role, where its effect is clearly demonstrated by comparing the results obtained at both seasons. With the increase in oil content and decrease in moisture content (as was the case towards the end of the cotton season) the percentage of the larvae that entered the resting stage was increased under all the temperatures used (except at 13°C). This effect was, however, much more pronounced at the intermediate temperature of 27°C., where the average percentage of R/TL had increased from 6.4% at August to 68.8% at September and less at 20 and 34°C. At 20°C. the percentage of R/TL had increased from 54.8

to 90.7% and at 34°C. from 6.45 to 25.1%, towards the end of the season. This was also shown in the difference between the rate of pupation of active larvae at both seasons. The results obtained at 20°C. were unexpected, as the difference in the percentage of R/TL in both seasons should increase than those at 27 and 34°C; however, it seems that this percentage had already risen to a very high value which could hardly be increased.

Temperature 13°C. seems to lie at or below the threshold of development of the larvae. In both seasons no development took place whatever the contents of the food were.

These results suggest to the authors that it is most probable that temperature is more important than food in governing the percentage of larvae that enter the resting stage. At the beginning of the season when the oil content of the food is low, temperature seems to be the only factor governing the initiation of diapause. However, high temperature (34°C.) and moderately high temperature (27°C.) express the same effect on that percentage. Towards the end of the season, when the oil content is increased, food interfere as a second factor beside temperature, in affecting the percentage of diapausing larvae. It increases that percentage at all the temperatures used above the developmental zeros of the insect, though its effect is mostly masked at very high temperature of 34°C. and less so as the temperature decreases, where its effect is clearly demonstrated. In other words, when both high temperature and food of high oil content are combined, the effect of temperature (which favours pupation) masters that of food (which favours diapause). At intermediate temperatures, the effect of food is clearly demonstrated, however, without masking the gradient effect of temperature.

It seems that, within the limits of this work, moderate temperatures and food of high oil content are the most suitable conditions for the onset of diapause in that insect, while very high temperatures favour pupation and very low temperatures favour diapause whatever the contents of the food.

Still, there is another factor which plays a minor role in the induction of diapause, however it should not be neglected. In August, there remained a small percentage of larvae that entered diapause inspite of the very high or moderately high temperatures combined with low oil content of the food; a condition which is most suitable for pupation. The amount of such larvae was about 6% at both 34 and 27°C. This is most probably due to genetical factors.

These conclusions as to the premium effect of temperature to food composition in initiating diapause in the pink bollworm, explains the high percentage of diapause (100%) in larvae collected from *bamia* at 6th December, 1957 (previously observed in the section of the "seasonal occurrence of the resting stage"). The low temperature (around 18°C.) prevailing during the period between 6th December, 1957, and 5th January, 1958, had masked the effect of food of low oil content (8.64%) and high moisture content (67.5%) and thus a high percentage of resting larvae resulted. At the same time, the increase in the percentage of R/TL in case

of larvae collected from cotton bolls towards the end of the cotton season, was due to the effect of food of high oil content which predominated when the temperature was most favourable (26.3°C. on the average).

THE EFFECTS OF OTHER FACTORS

1. Effect of chilling

Experiment

Fullgrown active larvae were collected in September 8th, 1957, from cotton bolls and these were directly transferred in the same day to the chilling chambers. Two temperatures were used, 1 and 8°C. Chilling periods ranged from 3-45 days, namely 3, 7, 15, 30 and 45 days. In conducting this experiment a stock of active larvae was put in each chamber and after the elapse of the above mentioned periods a group of larvae (50 larvae from each temperature) was taken out of the incubator and left under the room conditions in the normal specimen tubes. A group of control larvae was left without treatment under the room conditions (which fluctuated slightly during and after the chilling periods. At the end of thirty days the percentage of larvae that entered the resting stage in each treatment was compared with that of the control.

The same experiment was repeated in December 1st, 1957, on active larvae collected from bamia.

Results

The percentage of resting larvae at both seasons was not affected by such treatments. In September, the percentage of the ratio R/TL varied between 27 and 37.5% at all treatments as against 31.9% in the control. In December, this percentage ranged between 96 and 100%, while for the control it was 100%.

Chilling for 30 and 45 days at 1°C. increased the percentage of mortality at both seasons. This were 80 and 100% in September and 74 and 100% in December, for both chilling periods, respectively. The percentage of mortality in the control group was 6%.

2. Effect of irradiation with short waves

Experiment

Active larvae which were collected in 11th September, 1957, were subjected to irradiation in the next day. Two sources of short waves were used; a 2mg. radium needle for the low doses (less than hundred Röntigen (r)) and an X-ray apparatus for the higher ones (several thousand r). In the first case (low doses) the larvae were radially exposed around a center containing the radium needle. This was carried out as follows: a large Petri-dish, of diameter 25 cm. was filled with wax. Specimen tubes ($7 \times 1\frac{1}{2}$ cm) containing the larvae (10 each) were held vertically in pits bored

in the wax layer of the dish. These were arranged on the borders of three regular circuits having a common center, which was that of the dish. The diameters of these circuits were 5, 11 and 15.6 cm. The radium needle was fixed exactly in the center of the dish and the larvae were left exposed for 25 hours. The doses received by the larve at each circuit were calculated by the inverse square law of dosimetry and were found to be 67.25, 13.99 and 6.89 r at the 3 circuits respectively. In each circuit 50 larvae were used.

In case of higher doses (2500 and 5000 r) each 50 larvae were put in a Petri-dish of about 10 cm. in diameter, with fragments of cotton. The dish was placed over a waxy background and exposed to the nose of the X-ray apparatus, where the desired dose was delivered in one exposure. Calibration of the apparatus was previously made by a Seimens dosimeter. After exposure the larvae were left under the room conditions, with a group of controls, for 30 days. The same experiment was repeated in December 10th, 1957.

Results

Negative results were obtained by such irradiation at both times of the year. At September the percentage of the ratio R/TL varied between 39.6 and 47% for the treated larvae against 42.8% for the controls. At December that ratio was 97.8 to 100% and 98% for the controls. Variation in the percentage of mortality and pupation were nonsignificant altogether at all treatments.

3. Effects of mechanical and electrical stimuli

Experiment

Centrifugation at a speed of 3500 r/m for 10 minutes was used as a mechanical stimulus for the active larvae.

Electric shocks were given from an A.C. source of 8 and 200 V. Duration of the stimulus in case of the 8 V current ranged between 1-5 seconds, namely 1, 3 and 5 seconds and was measured by a stop watch. In case of the 200 V current the leads of the current just touched the tips of the larvae. Time could not be accurately measured, but it did not exceed half a second. In such treatments (electrical stimulus) each larva was introduced in a small glass tubing of about 4 mm. in diameter and 2.5 cm. in length. The terminals of the current were let to touch the head and tail of the larva for the required time.

Both mechanical and electrical stimuli were tried on active larvae at 7th September, 1957, and 6th December, 1957, with the same technique and in each case 50 larvae were used for each treatment and for the control.

Results

Such treatments were ineffective in changing the percentage of active larvae that entered diapause at any time in the season. In every case the ratio R/TL varied slightly from that of the control.

Using both stimuli the percentage of R/TL at September varied between 36 and 44% for the treated larvae and 40.8% for the controls while at December it ranged between 96 and 100% against 97.8% for the controls.

The larvae which had been centrifuged appeared in a turgid form after treatment, but they regained their normal sizes in about an hour. The larvae which were shocked by the 8 V current looked quite normal after treatment, while those receiving the 200 V stimulus appeared sluggish and died within several days later. In case of the latter stimulus burns also appeared at the points of contact of the terminals with the cuticle and sometimes vomiting occurred.

Discussion

The negative results obtained when applying the previously mentioned stimuli (chilling, irradiation, mechanical or electrical stimuli) on the active larvae just before entering the resting stage, indicate that they can neither initiate diapause at a time when the normal trend of most of the larvae is towards pupation (at September), nor inhibit its production when the general trend of the larvae is towards diapause (at December). The onset of diapause in this pest is more deep to be induced or inhibited by such factors.

SUMMARY

(1) The percentage of larvae that entered the diapause stage under the natural conditions of the laboratory increased gradually towards the end of the cotton season and still higher values were obtained at end of the year, irrespective of the type of food.

(2) The average body weight of the fourth stage active larvae expressed no effect on the percentage of larvae that entered the resting stage, provided the temperature was suitable for the onset of that stage.

(3) Generally speaking, the percentage of active larvae that entered the resting stage at one and the same time in the year was inversely proportional to temperature. At the same time this percentage, under one and the same temperature, increased towards the end of the cotton season where the only difference was in the composition of the food. Relative humidity had very slight effect on that percentage and can be neglected.

(4) Moderate temperature and food of high oil content are the most suitable conditions for the onset of diapause, while very high temperature favours pupation and very low temperature favours the arrest of development whatever the contents of the food.

(5) The factors which actually affect the percentage of active larvae that enter the resting stage were arranged in the following order according to their relative importance: temperature, food and rhythm.

(6) The treatment of the mature fourth stage active larvae with stimuli such as chilling for 3-45 days at temperatures of 1 and 8°C., irradiation with short waves with doses ranging between 6.89 and 5000 r, centrifugation at a speed of 3500 r/m for 10 minutes and reception of electric shocks from an A.C. source of 8 and 200 V for 1-5 seconds in the former current and for less than half a second in the latter one, had neither initiated diapause at a time when the normal trend of most active larvae was towards pupation (at September), nor inhibited its production in the late season (at December) when the short-cycle larvae were exceptional.

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FACTORS AFFECTING TERMINATION OF THE RESTING STAGE OF THE PINK BOLLWORM, *PECTINOPHORA GOSSYPIELLA* SAUNDERS

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INTRODUCTION

The most important factors affecting the termination of diapause stage in insects are temperature, humidity, chilling, photoperiod, exposure to the vapours of chemicals and mechanical or electrical stimuli. Complete data on the different factors affecting termination of diapause in the pink bollworm, *Pectinophora gossypiella* S., are wanting. Temperature, relative humidity and moisture are the only factors dealt with by many authors. BINDRA (1927) is of the opinion that high temperature is the effective factor for the emergence of the long-cycle larvae. On the contrary, exposure to high relative humidity or water in the form of rains or through wetting the resting larvae with water, were thought to be of great importance in this respect by BALLOU (1920), FENTON and OWEN (1931), BEDFORD (1934), CHAPMAN and CAVITT (1934), TAYLOR (1936), SQUIRE (1937, 1940 a and b), KHAN (1938) and FIFE (1949). Combinations of high degrees of temperatures and relative humidities or water gave positive results by WILLCOCKS (1916), LOFTIN, MCKINNEY and HANSON (1921), WILLIAMS (1924) and BISHARA (1930 and 1936). WILLIAMS (1926) correlated the development of the attack by this pest with the state of development of the cotton crop. The effect of temperature and relative humidity or moisture in terminating the diapause stage in other insect larvae is widely known. TOWNSEND (1926) found that frequent soaking in water of the hibernating larvae of the codling moth (together with a certain degree of cold exposure at 50°F.) was efficient in interrupting its hibernation. TAYLOR (1936) tested the effect of different relative humidities on 3 months old resting larvae of *Platyedra erebodoxa* and on another unidentified species of *Platyedra*. He observed that the relative humidities 80, 90 and 100% had initiated pupation in a few larvae in two weeks and within a

month, all the larvae pupated. WALOFF (1949) working on diapausing larvae of *Ephestia elutella*, observed that the average period preceeding pupation at 25°C. and 70% relative humidity was increased when the larvae were subjected to these conditions in early diapause ages. He concluded that the production of pupation hormone is delayed until a certain weight loss, accompanied by elimination of waste products, is reached. The larvae at outdoor conditions reach a certain physiological state in which pupation is delayed not by the original diapause-inducing factor, but by the low outdoor temperature which delays immediate pupation.

In other insect stages, FERRIS (1919) found that emergence of adult *Margarodes* could be brought about by immersing the diapausing cysts in water for a considerable time. LEES (1955) had shown that diapausing eggs of *Locustana pardalina* were reactivated at temperatures as high as 35°C. LEES gives further examples for adult insects requiring high temperature for the completion of the diapause development, such as the beetle *Leptinotarsa* and the californian zygaenid *Harrisina brillians*. In the former example, exposure to a constant temperature of 25°C. eventually stimulated the beetle to emerge from the soil in two or three months, while at 30°C. it required only about three weeks.

The effect of other factors such as chilling, mechanical or electrical stimuli and exposure to the vapours of chemicals on the termination of diapause in the pink bollworm, have never been dealt with. However, such factors are well known to play definite roles in interrupting even the intense diapause of some other insects.

It is a well known fact that the subsequent growth of many resting insects can be brought about after the exposure to temperatures that are too low to permit the growth of the non-resting stages (LEES, 1955). This type of growth is amongst the most striking features of the diapause conditions. Data on this subject are plentiful.

BAUMBERGER (1914), working on the codling moth larvae, observed that storage at low temperature ($\pm 53^{\circ}\text{F.}$) for 7-14 days, but not longer, followed by subjection to high temperature ($86-96^{\circ}\text{F.}$) resulted in early pupation in some of the larvae. TOWNSEND (1926) working on the same insect, obtained similar results when the storage temperature was 50°F. At 32°F. , however, a higher percentage of pupation was obtained when the storage period was prolonged from 7-14 days to 30 days and then exposed to high temperatures. In the lepidopterous species such as *Phalera bucephala*, *Smerinthus ocellatus*, *S. ligustri* and *Loxostege sticticalis*, which enter diapause as larvae or pupae, the optimum chilling temperature required to complete diapause development lies close to or just above zero (DANILEVSKY, 1949).

Examples of other insect stages are numerous. ROUBAUD (1922) terminated the hibernation of the blowfly *Lucilia* by prolonged cold treatment ($32-39^{\circ}\text{F.}$) for 3-4 weeks. The eggs of *Melanoplus differentialis* required a mean incubation period of 89 days at 23°C. , and 28 days at 30°C. , but after exposure to outdoor winter conditions for 168 days, the eggs hatched promptly in only 12 days when incubated at 23°C. (BODINE, 1925). ANDREWARTHA (1943), working on the diapausing eggs of

Austroicetes cruciata, had showed that if these eggs were chilled for 60 days at 10°C., they hatch promptly and uniformly when subsequently incubated at 25°C. The same period of chilling at 6 and 13.5°C. was much less effective and fewer eggs hatched when incubated at higher temperatures. BERTANI (1947) showed that when diapausing adults of *Drosophila nitens* were exposed to low temperatures (10 days at 2-5°C.) one month from the beginning of the diapause, after which they were kept at 25°C., they terminated their diapause successfully and reproduced actively. When the diapausing eggs of *Bombyx mori* were kept worm for 30 days after laying, they required only 60-70 days of chilling at 5°C before 90% of the eggs had hatched at a higher incubation temperatures, but at 2.5°C chilling the eggs for 80 days was required to get the 90% hatching and at 12.5°C. over 100 days of chilling was required to get the same percentage of hatching (MUROGA, 1951).

THERON (1943) was the first author who studied the effect of irradiation with short waves on terminating diapause of the codling moth larva. He treated resting larvae with gamma rays from a two mg. radium needle at various distances (2-6 cm.) and for periods of thirty minutes up to ninety six hours. However, negative results were obtained by him in every case. The same results were obtained when applying electric shocks of 6 and 220 V for quarter of a second, or when centrifuging the resting larvae at 3500 r/m for three minutes. However, the greatest success in breaking its dormancy was by removing the hibernating larvae from their cocoons and leaving them to respin in fresh corrugated paper strips. It was observed that some of these larvae had pupated after only one or two respins, the majority after the third fourth respins.

The application of fat solvents and strong oxidising agents to resting stages, have been tried by many authors to break up the diapause of some insects. Positive results were obtained by SAUTET (1933) in case of the larvae of *Anopheles*. He found that the addition of moderate quantities of oxidising agents, such as eau de Javelle or potassium permanganate, reactivated some of the larvae, especially if this treatment was preceded by a moderate increase in temperature. Exposure to the vapours of fat solvents such as xylol, carbon tetrachloride, ethyl bromide and iodide readily ended the larval diapause in *Loxostege sticticalis* (PEPPER, 1937). In other insect stages, KOGURE (1933), showed that *Bombyx* eggs could be reactivated by immersion in dilute HCl or H₂SO₄. The diapausing eggs of *Melanoplus differentialis* when treated with xylol and supplied with water, will resume development (SLIFER, 1946). BOYCE (1931), working on the diapausing pupae of *Rhagoletis completa*, had reported partial success in interrupting its dormancy by soaking in certain chemicals, or by exposure to certain gases. He found that after four months, pupae treated with potassium thiocyanate showed an emergence of 8% as against 2% in the controls, and after six months potassium cyanate and thiourea gave an emergence of 22 respective 21% as against 12% in the controls.

In case of diapausing eggs, the action of chemicals was suggested by LEES (1955) to modify the properties of the egg membranes in such a manner that the

physical conditions necessary for the growth of the embryo are restored. In *Melanoplus* eggs, xylol treatment allowed the eggs to take up the water, which is a requirement for normal development. In post-embryonic stages, chemical (or mechanical) treatments may cause increased stimulation of some centers of "humoral control", such as the brain, so that the normal mechanism of control is brought into action prematurely (LEES, 1955).

On the other hand, chemical treatments failed altogether in terminating diapause of some other insects. THERON (1943) working on the diapausing codling moth larvae, obtained negative results when using the vapours of carbon tetrachloride, xylol, toluol, nitrobenzene, ethyl iodide, chloroform and others, with different concentrations from 1 cc. down to 0.061 cc./L, for six hours exposure. Fat solvents and strong oxidising agents had also been tried on the pupae of the cherry fly *Rhagoletis cerasi* (WEISMANN, 1950), but without success.

In this work the effect of a wide range of temperature and relative humidities was tested for the breaking up of diapause in the pink bollworm. Besides, various other stimuli were also applied on the resting larvae at two different times in the diapause period in order to compare the response of the larvae at different ages.

OBSERVATIONS ON THE DIAPAUSE STAGE

1. Duration of the resting stage (average-sized larvae)

Much controversy is met with as to the normal duration of the resting stage of the pink bollworm. GOUGH (1916) found resting larvae which were over two years old in seeds of Indian cotton imported to Egypt. WILLCOCKS (1916) stored large numbers of bolls in November, 1913, in an outdoor cage. He observed that moths continued to emerge till August, 1915, a period of nearly two years. In addition, he observed that the maximum emergence of moths from the resting stage took place during the period between July to the end of September. BUSCK (1917) found live larvae of 18 months old when compressing cotton seeds into small bales.

In this work it was intended to add further knowledge as to the duration of the resting larvae which entered that phase at different months of the year. Active larvae were brought to the laboratory in 2nd September, 2nd October and 6th December, 1957. These were put between thin layers of cotton fibres inside breeding boxes and left to enter the resting stage under the room conditions. After 30 days, the remaining alive larvae of each collection were considered as resting larvae. This period (30 days) was suggested by the authors in a previous work (EL-SAYED and RUSTOM, 1960) to be a safe and reasonable limit between the active and resting phases of the larva. Periodical observations (every week) were made for each collection of larvae till they died or pupated. The 30-days limit was considered as the zero point for the resting stage for each collection and consequently, in calculating the

duration of the resting larvae the zero point was taken as the start point and the day of pupation (day of observation) as the end point of the diapause stage.

Results

The mortality increased in the larvae that entered the resting stage late in the year, being 4, 10.5 and 27.2% of the larvae diapausing in September, October and December, respectively. On the other hand, the average duration of the diapause phase decreased gradually in those larvae entering this stage late in the year. The average duration of the larvae brought to the laboratory in September was 161 days, while it was 136 days for those brought in October and 94.8 days for those brought in December. Differences between the averages of the three successive months are significant. In addition, it was clear from our results that the maximal emergence of the larvae from the resting stage (pupation) occurred in very near periods in the three collections. Thus, in the larvae brought in September about 80% of them had pupated in the period between 19th March and 23rd April, 1958; in those brought in October approximately the same percentage had pupated in the period between 21st March and 18th April, 1958, while in those brought in December, this percentage was nearly reached in the period between 23rd March and 27th April, 1958. Referring to the charts of the recorded temperature and relative humidity in these periods it was observed that the first increase in temperature had only taken place in nearly the same periods of the year. Relative humidity on the other hand, had not seriously changed. Thus, it can be concluded that the maximal emergence from the resting stage, for all collections, occurred at the first increase in temperature of the next year (roughly in the period between 19th March and 27th April). Pupation proceeded as the hot weather of the summer prevailed and it was independent of the date of entering the quiescent stage. Not a single case was recorded for larvae passing summer in the resting stage.

Another point of interest is the emergence of the long-cycle larvae which took place in two major waves. This was particularly manifested in case of the larvae which entered diapause in October and December. This is in broad agreement with the observations of BISHARA (1936). However, the several optima recorded by him may be probably, due to the difference in the time at which these larvae had entered the resting stage in the previous season.

2. Relationship between the average body weight of larvae and duration of the diapause phase

WALOFF (1949), working on the diapausing larvae of *Ephestia elutella*, observed a direct relationship between the initial larval weight (when entering this phase) and the length of the quiescence period. He stated that the heavier larvae have longer periods of rest.

In the present work, a similar experiment was carried out on the resting larvae of the pink bollworm. Active fourth stage larvae of the extreme sizes (large

and small) were brought to the laboratory in December 29th, 1956. These were left under the room conditions for 30 days after which time, a number of larvae of each size was selected intact inside their cocoons and put in specimen tubes. Periodical observations were made for determining the rate of pupation till the end of the experiment. Estimations of the average larval size, water and fat contents of each larval size were determined by using samples of the active stage when first brought to the laboratory.

Results

It was clear that the percentage of survivors of the large-sized larvae (average weight 35.4 ± 1.14 mg.) was about twice that of the small-sized ones (average weight 13.9 ± 1.27 mg.), being 81.8 and 43.7% of both sizes, respectively. The average duration of the small larvae (72.2 days) is slightly, but significantly, lower than that of the large larvae (83.7 days). That means that the size of the larva (and its body weight and fat content) is a factor which significantly affects the duration of the resting stage. This result is in agreement with that of WALOFF (1949) on *Ephestia elutella* larvae.

3. Fate of uncocooned resting larvae

During the course of the present work, it was noticed that some of the resting larvae left their cocoons, while others did not spin cocoons altogether during the major part of the resting stage. Such larvae were observed to crawl about very inactively or to remain inbetween cotton fibres in a motionless state, but they never feed, even if afforded ground cotton seeds.

The fate of such larvae was studied on a group of 120 larvae, selected in February 23rd, 1957, from a stock of 40 days old larvae. These were transferred to specimen tubes, in groups of 10, with fragments of cotton fibres and left under the laboratory conditions. The rate of mortality and pupation were checked periodically every week, until all of them either died or pupated. Results were compared with that of a group of control larvae (from the same stock, but intact inside their cocoons).

Results

The percentage of mortality of uncocooned resting larvae was much higher than that of the controls, being 55 and 17.5% in both cases, respectively. In addition, the average duration of such larvae was 36 ± 3.9 days, while that of the controls was 48.6 ± 4.2 days, the difference 12.6 days is highly significant. That means that there is a tendency of such larvae to terminate their diapause in a shorter time than those which are inside cocoons.

THE EFFECT OF TEMPERATURE AND MOISTURE

1. Effect of different temperatures and relative humidities

Experiment

In January 1st, 1957, samples of 5-days old resting larvae were exposed to different temperatures of 34, 27, 20 and 13°C. With each temperature four relative

humidities were combined, namely 20, 40, 60 and 90%. Fifty larvae were used for each combination of temperature and relative humidity. These were carefully selected from the stock with their cocoons intact. Each ten larvae were introduced in a tube, covered with muslin and held with rubber band. Observations were made every four days for three successive times, then every week till the end of the experiment. Those larvae which pupated or died were removed from the tubes. In calculating the duration of the larvae, their previous age (5 days) was not taken in consideration and the larvae which died during the experiment were also neglected.

In March 10th, 1957, the same experiment was repeated on resting larvae selected from the same stock, which was then 66 days old.

Results

(a) Young resting larvae (5-days old)

High percentage of mortality (100%) occurred at low temperature of 13°C. coupled with the four relative humidities used, and at high temperature of 34 and 27°C. coupled only with 20 and 40% R.H. At 13°C. larvae remained alive for very long periods up to 411 days while the maximum number of mortality took place in the period between 264-285 days at all humidities. At 34 and 27°C. complete mortality took place in a maximum of 12 days and the larvae appeared very dry and solid after death. In all other combinations the normal average of mortality was between 0-12%.

By analysing the data concerning the average duration of the diapausing larvae at the same temperature but subjected to different relative humidities, it is seen that significant differences are found only in two cases. The first case is at temperature 34°C. where the average duration of the larvae decreased from 24.9 to 19.1 days by increasing the relative humidity from 60 to 90%. The second case is at 20°C. where it decreased from 102.8 to 87.8 days by increasing the relative humidity from 20 to 90%. In all, the other conditions of experiments nonsignificant changes in the average duration of the diapausing larvae were achieved by changing the relative humidity.

On the other hand, by studying the effect of temperature changes on the average duration of the diapausing larvae at the same relative humidity, it is observed that the average duration increased steadily and successively with the lowering of temperature from 34 to 27 to 20°C. Differences are in every case highly significant. The total average duration were 22,36.1 and 94.1 days at the three temperatures, respectively.

(b) Old resting larvae (66-days old)

It was noticed that 100% mortality occurred only at 13°C., combined with all R.H., when the resting larvae are comparatively older (66 days old). The maximum number of dead larvae at this temperature occurred in the period between 264-285 days, while the maximum longevity was 369 days. In other combinations

of temperatures and relative humidities, mortality was more or less the same, ranging between 0.12%. The average duration of the larvae was slightly affected by variation in relative humidity within one temperature. At 34°C., the average durations of the diapausing larvae were 14.6, 18.4 and 14.95 days at the relative humidities 20, 40 and 60%, respectively. The differences between these averages are nonsignificant. At 34°C. and 90% relative humidity, the average duration being 8.33 days is slightly and significantly lower than at any of the previous humidities. At 27°C. significant differences between the average durations of the diapausing larvae are only observed with the stepping up of the relative humidity from 50 to 60%, otherwise, all differences are nonsignificant. At 20°C., the differences between the average duration of the larvae at all the relative humidities are nonsignificant altogether.

By comparing the effects of changing the temperature on the average duration of the resting larvae at the same relative humidity, it is observed that duration of the larvae decreased greatly with increasing temperature from 20 to 27°C. Further increase in temperature up to 34°C. did not significantly decrease the average duration of the larvae, except at 20% relative humidity. The total average duration at 20, 27 and 34°C. were 37.3, 15.18 and 14.07 days, respectively.

By comparing the results obtained at both ages of larvae, the following facts are revealed:

(1) In both ages the percentage of mortality was mostly similar, being 0-12%. However, in case of the 5-days old larvae, mortality increased to 100% at temperatures of 34 and 27°C. coupled with low relative humidities of 20 and 40%. On the other hand, in case of the 66-days old larvae, the percentage of mortality was normal even at high temperatures coupled with low relative humidities. At 13°C. the percentage of mortality was 100% at all the relative humidities used and for both ages of the larvae. Though, some of the five days old larvae could survive for 411 days, while the maximum longevity of the 66-days old larvae was 369 days.

(2) In both ages, the average duration of the resting larvae was inversely proportional with temperature. The only exception was that in case of the older larvae where nonsignificant difference was observed with the increase in temperature from 27 to 34°C. The effect of relative humidity, on the contrary, was not clear except in few cases only in both ages. The average duration of the older larvae was significantly shorter than that of the younger ones. This fact is true when comparing both ages at all similar conditions of temperature and relative humidity. The difference between the total average duration of larvae at both ages under the same temperature was smallest at 34°C. and increased successively with the decrease in temperature.

(c) Rate of pupation of the 5 and 66-days old resting larvae

It was evident that the rate of pupation was faster in the higher temperatures. In addition, the rate of pupation of the 66-days old larvae was faster at all tempe-

ratures than that of the 5-days old larvae. The difference in the rate of pupation of both ages was greatest at 20°C., less at 27°C. and smallest at 34°C.

2. Effect of soaking with water

Experiment

In December 12th, 1957, samples of resting larvae (1-day old) were soaked in water, with their cocoons intact, for 8, 24, 48 and 72 hours. The cotton fibres and the cocoons were heavily wetted with water, but not to such an extent to suffocate the insects themselves. At the end of each soaking period water was dried well on a filter paper, and larvae were transferred to specimen tubes and left under the room conditions with a group of controls. Observations were made periodically every week. Fourty-five larvae were used for each soaking period and for the control group.

Results

The percentages of dead larvae and those which terminated diapause (pupated) after the application of water for different periods, as well as the average duration of the resting stage, were observed. It is clear that the percentages of mortality for those larvae soaked for 24, 48 and 72 hours were slightly higher and consequently those of pupation were slightly lower, than the corresponding percentages in the control group. On the other hand, differences between the average duration of the larvae soaked for different periods and that of the controls were altogether nonsignificant. This is an indication of a negative correlation between wetting the resting larvae with water (for periods up to 72 hours) and termination of the diapause stage, at a time of the year in which the general trend of most of the resting larvae is not towards pupation (December).

Discussion

In case of the younger resting larvae (5-days old) mortality was 100% both at low temperature of 13°C. and at high temperatures of 34 and 27°C. when coupled with low relative humidities of 20 and 40%. However, different causes had lead to that high percentage of mortality in the two cases: At 13°C. mortality was only due to this low temperature, while relative humidity has no effect at all. This is proved by the fact that the 100% mortality occurred under all relative humidities from 20 to 90%, and that the maximum number of dead larvae was found after the elapse of the same periods at all humidities (between 264-285 days). This result is in accordance with the results obtained at that temperature in case of the active stage where complete cessation of development occured (EL-SAYED and RUSTOM, 1960). On the other hand, at 34 and 27°C. mortality was due to dessication at the lower humidities applied. It took place very rapidly and in no more than 12 days. This is proved by the fact that the larvae appeared very dry and solid after death, and moreover, raising of the relative humidity to 60% or 90% at the same temperature lowered mortality to normal again. In case of the older larvae (66-days old), the same result

was reached at 13°C., where complete stoppage of development was caused by this low temperature. That the lethal effect of dessication was not outstanding at higher temperatures (34 and 27°C.) coupled with low relative humidities at that age, may be explained by the fact that the majority of the larvae had pupated before the effect of dessication became injurious.

The average duration of the resting stage was inversely proportional with temperature in both ages (with the exception of the older larvae where nonsignificant difference was obtained by rising temperature from 27 to 34°C.), a fact which shows that temperature is an important factor governing the duration of the diapause stage. Humidity, on the contrary, plays a very minor role in this respect. This is confirmed by the fact that at intermediate temperatures of 27 and 20°C., which approximate the optimum temperature, changes in the relative humidity were mostly of a negligible effect, where one would expect its evident influence if it is an important factor. This is further confirmed by the results obtained in the experiment of soaking with water.

The fact that the average duration of the older larvae (66-days old) was much shorter than that of the newly resting ones (or in other words the rate of pupation was faster), indicates that a second factor other than temperature plays a role in terminating the diapause stage. It has been proved above that relative humidity plays a negligible role in terminating the diapause stage. Further, the larvae lived in the same conditions of illumination inside the incubator, a fact which eliminates the effect of light as a factor. One of the main differences between the younger and older larvae is the amount of reserve food and more specially in the form of fat content. Newly resting larvae contain higher amounts of fat than older ones. This was proved in a separate work on this insect by J.J. MANSOUR-BEK and Z. RUSTOM (under publication). This means that the lower amount of fat the faster the rate of pupation or the shorter the duration in the diapause stage. However this does not deny the gradient effect of temperature on the rate of pupation of larvae having the same fat content.

Under one and the same temperature, the difference in the average duration of the resting larvae at both ages was smallest at 34°C., high at 27°C. and still higher at 20°C.; a fact which reveals the masking effect of high temperature to fat content on the average duration of the larvae: while at intermediate temperatures the effect of fat content was clearly manifested, though in a gradient way due to the gradation of temperature. These observations suggest that the effect of temperature was superior to that of fat content of the larvae in terminating diapause of the pink bollworm. Fat content, comes just second to temperature in importance; a picture which is similar to that found in case of the active stage of this insect (EL-SAYED and RUSTOM, 1960), where temperature was dominant to food content in initiating diapause.

In case of the older resting larvae, where the fat content is low, it seems that high temperatures above 27°C. have nearly the same effect on the rate of pupation.

This may explain the similar results of the average duration of 66-days old larvae at 27 and 34°C. Parallel results were also obtained in case of active larvae feeding on food of low oil content, where temperatures 27 and 34°C. resulted in close percentages of R/TL (EL-SAYED and RUSTOM, 1960).

The importance of temperature as a factor governing diapause development of the pink bollworm is in agreement with the findings of many authors on this pest, e.g. WILLCOCKS (1916), WILLIAMS (1924), BINDRA (1927) and BISHARA (1930 and 1936). However, these authors and many others, had further stressed moisture as another important factor in this respect; a fact which is not in agreement with the findings of the present work. Many of these authors had mostly based their conclusions on mere observations in the field on resting larvae of unknown age and they did not confirm their results with experiments conducted under controlled conditions. Even in the latter case, they carried it out imperfectly. SQUIRE (1940 b), was the only who referred to the importance of fat content of the resting larvae in terminating the diapause stage, though he relied much on the effect of moisture in bringing the lowered level of fat required for diapause termination.

In other insect stages, temperature was observed to be the determining factor in diapause of *Locustana pardalina* eggs, *Leptinotarsa* and *Harrisina* adults (LEES, 1955). The importance of body constituents in accelerating the termination of diapause was stressed by WALOFF (1949) for the diapausing larvae of *Ephesia elutella*.

THE EFFECTS OF OTHER FACTORS

1. Effect of chilling

In the present work, chilling was performed on the resting stage of the pink bollworm in two ways. In the first, larvae were chilled at low temperature and then introduced to high temperature; in the second, chilled larvae were transferred to the normal temperature of the laboratory. In this way the process of chilling was known wheather it has any effect alone or when coupled with high temperature.

Experiment

In November, 1957, several lots of 120 resting larvae each, about one month old and intact inside cocoons, were transferred to chilling chambers of 1 and 8°C. Chilling was continued for different periods of 3, 7, 15, 30 and 45 days, at both temperatures. The time of transfer of the treated larvae to these chambers was arranged so that the five chilling periods end in the same day. Each lot of larvae was then divided into two halves (of 60 each) one kept at 34°C. and the other left under the room conditions. Control larvae were directly transferred in the same day either to 34°C. or to the room. The rate of mortality and pupation were checked periodically every 5 days and duration of the larvae was considered from the day

of transfer to 34°C. (or to room) to the day of pupation (day of the check). Results in each case were compared with those of the controls.

Results

It was shown that chilling was only significantly effective in reducing the average duration of the larvae when performed at 1°C. for 15 or 30 days. This is true whether the chilled larvae were transferred to high temperature (34°C.) or to the normal temperature of the laboratory. In the first case (34°C.), the average duration of the larvae were 15.5 and 13.7 days after chilling for 15 and 30 days respectively, as against 19.1 days for the controls. In the second case (room conditions) the average duration were 90 and 81.1 days after chilling for 15 respective 30 days, as against 96.4 days for the controls. In all other treatments the differences between the average duration of the chilled larvae and the controls were nonsignificant altogether. Percentage mortality was high at long chilling periods, reaching about 100% after 45 days of chilling at 1°C.

The results obtained here by chilling at 1°C. for 15 or 30 days agree with those achieved by BAUMBERGER (1914) and TOWNSEND (1926) for the codling moth larvae, by DANILYEVSKY (1949) for the various species of Lepidoptera experimented by him, as well as by BODINE (1925) for the eggs of *Melanoplus differentialis*, by ROUBAUD (1931) for *Lucilia*, by ANDREWARTHA (1943) on the eggs of *Austroicetes cruciata*, by BERTANI (1947) for adult *Drosophila* and by MUROGA (1951) for *Bombyx* eggs.

2. Effect of irradiation with short waves (gamma and X-rays)

Experiment

Different doses of short waves were tried to break the diapause of the pink bollworm, at two ages of the latter, 1 and 69 days old. The first experiment was carried out in January and the second in March, 1957, using the same sources and technique followed in case of the active stage (EL-SAYED and ROSTOM, 1960). The resting larvae received doses of 6.89, 13.99, 27.5, 55.96, 67.25, 269, 2500 and 5000 röntigens. The larvae were kept under the laboratory conditions after treatment. The percentages of mortality and pupation and the duration of the larvae in each treatment were compared with that of a control group of larvae of the same age. Fifty larvae were used for each dose and for the controls.

Results

The average duration of the larvae 1-day old ranged between 90.9 ± 2.73 and 101.1 ± 3.1 days after receiving any of the doses mentioned above, as against 96.7 ± 1.89 days for the controls. In case of the older larvae (69 days old) the average duration ranged between 21.3 ± 1.65 and 28.9 ± 2.05 days as against 25.6 ± 1.46 days for the controls. At both ages of the larvae the differences between the average duration of the treated and control larvae were nonsignificant. Besides, the percentage mortality did not vary greatly from the control groups.

It can be consequently concluded that such treatments with short waves do not affect the termination of the resting stage whatever the dose used or the age of the larvae (within the limits used). These results agree with that obtained by THERON (1943) for the diapausing larvae of the codling moth.

3. Effect of mechanical and electrical stimuli

Experiment

Mechanical (centrifugation) and electrical stimuli were tried to terminate the diapause of the larvae of the pink bollworm at two ages. In January 1957, a sample of larvae one day old, was centrifuged inside their cocoons for 10 minutes at a speed of 3500 r/m. In another sample, the larvae were enforced outside their cocoons, centrifuged naked in the same way as before and then introduced in specimen tubes with cotton fibres to respin.

Electric shocks were carried out exactly as done in the case of active larvae (EL-SAYED and RUSTOM, 1960), i.e. from an A.C. source of 8 and 200 V for 1, 3 and 5 seconds in case of the first voltage used and for not more than half a second in case of the second voltage.

After application of such stimuli, the treated and control larvae were left at the room conditions. The rate of mortality and pupation were observed periodically.

In March of the same year, the experiment was repeated on older larvae (66 or 81 days old).

Fifty larvae were used in each case.

Results

It was noticed that the average duration of the resting larvae of both ages had not significantly changed from those of the control group. Treating the larvae with the 200 V current was however completely fatal to the larvae (and this took place in few days after treatment).

These results agree with those obtained by THERON (1943) for the diapausing larvae of the codling moth.

4. Effect of chemicals

Experiment

The effect of exposure to the vapours of volatile chemicals was tested in January on five days old resting larvae. Groups of 50 larvae inside cocoons, were put in desiccators of capacity 6.87 L each. In each desiccator a chemical was pipetted and a greased cover was rapidly fixed. Chemicals used were: carbon tetrachloride, ethyl iodide, ethyl succinate, toluene, nitrobenzene, methanol, chloroform, xylol, methyl bromide, and solid iodine. The concentrations of all the chemicals were 1 cc./L (or 1 gm./L in case of I₂) and duration of exposure was 24 hours. The experi-

ment was carried out at the room temperature and the larvae were also left there after treatment, with a group of controls. Observations were carried out every day in the first week and then every seven days till the end of the experiment.

In March a similar experiment was conducted on 75 days old larvae. Concentration of the chemicals was slightly changed. Chemicals, which caused 100% mortality in short times (few days) in the first experiment, were diluted to 0.2 cc./L., otherwise the concentrations were raised up to 3 cc./L. Duration of the exposure was also 24 hours.

Results

The percentage of mortality varied greatly after treatment with the different chemicals and reached 100% in many cases. However, the average duration of the remaining larvae were about the same as that of the control group; the differences were in every case nonsignificant. This was true for both ages of the resting stage.

It can be concluded that such treatment have negative effects on ending the diapause stage in the pink bollworm. This result is similar to the findings of THERON (1943) for the codling moth larvae and of WEISMANN (1950) for the pupae of *Rhagoletis*, while it contradicts those of SAUTET (1933) for *Anopheles* larvae, of PEPPER (1937) for *Loxostege* larvae, and of KOGURE (1933) for *Bombyx* eggs, etc., who recorded positive results in terminating diapause by chemicals.

5. Effect of enforced respinning

Experiment

In December 1957, 50 resting larvae of one day old were enforced outside their cocoons, transferred to other specimen tubes with fresh cotton fibres and left to respin at the room conditions. This process was repeated several times until all the larvae died or pupated. Results were compared with that of a group of 50 control larvae. The same experiment was repeated in March on 81 days old larvae, to know the difference in response at different ages.

Results

In the younger stage (1 day old), most of the larvae had repeated spinning for three times, and in each time 84, 90 and 70% of the larvae had respinned, respectively. After that, no cocoons were constructed. The larvae stayed inbetween cotton fibres until they died or pupated. The percentage of mortality in this age of the resting stage was exceedingly high when compared with that of the controls, being 80 as against 24% in the control larvae. The average duration of the remaining larvae (114.2 days) was slightly lower than that of the controls (121 days), however the difference proved to be highly significant. When this process of repeated spinning was applied to the older larvae, (81 days old) negative results on terminating diapause were obtained. The larvae had only respinned twice and the percentage of mortality was close to that of the controls.

This experiment shows that enforced respinning is only effective in terminating diapause in the pink bollworm when applied early in that stage. However, the difference in the average duration of the treated and control larvae, being about 7 days, is quite small.

These results agree in part with the observations of THERON (1943) on the codling moth larvae, where the greatest success in breaking up diapause in this insect was achieved by the process of repeated spinning.

Discussion

The negative results obtained by applying most of the previously worked out factors (chilling, irradiation, mechanical and electrical stimuli, chemicals and enforced respinning) on terminating the resting stage in the pink bollworm indicate that diapause in this pest is mostly of the intense type which is not easily broken up by such stimuli. In the few cases where such treatment gave positive results in this respect (chilling for 15 or 30 days at 1°C. and enforced respinning of the young resting larvae) the difference between the average duration of such larvae and the control group was quite small and did not exceed 15 days. Hence, we should not exaggerate the importance of these stimuli on terminating the diapause phase in *Pectinophora gossypiella* S.

SUMMARY

(1) The average duration of the resting larvae under the natural conditions of the room decreased gradually in larvae entering this stage late in the year, being 161, 136 and 94.8 days for larvae entering diapause at September, October and December respectively. The maximal emergence from that stage occurred at the first increase in temperature in the next year, roughly in the period between March 19th and April 27th, irrespective to the date of entering this stage. Not a single case was recorded for larvae passing the summer under this conditions.

(2) The average duration of the small-sized larvae was found to be slightly lower than that of the large-sized ones.

(3) The average duration of the larvae which passed most of the resting period outside cocoons was slightly lower than that of the larvae that passed that stage normally inside their cocoons.

(4) Generally speaking, the average duration of the resting larvae was inversely proportional to temperature at any age of that stage. Relative humidity in the range between 20-90% proved to be not effective, as well as soaking the larvae for 8-72 hours at December. At the same time the average duration of the older larvae was much lower than that of the younger larvae. This lead to the conclusion that temperature and fat content of the larvae are responsible for the termination of the resting stage, however, temperature has proved to be superior to fat in this respect.

(5) Chilling the resting larvae for 3-45 days at 1 and 8°C. followed by transferring the larvae to 34°C. or to room conditions was tried to terminate the diapause. Positive results were obtained only when the larvae were chilled at 1°C. for 15 or 30 days.

(6) When resting larvae of different ages were irradiated with short waves ranging between 6.89 and 5000 roentgen, centrifugated at a speed of 3500 r/m for 10 minutes, given electric shocks from an A.C. source of 8 or 200 V for 1-5 seconds in the previous voltage and for less than half a second in the latter volt, or exposed to the vapours of volatile chemicals (carbon tetrachloride, ethyl iodide, ethyl succinate, toluene, nitrobenzene, methanol, chloroform, xylol, methyl bromide and solid iodine) with different concentrations for 24 hours, all these treatments gave negative results as to the breaking up of this stage.

(7) Enforced respinning of the resting larvae gave positive results when the larvae were still young in the resting stage.

(8) Diapause of this pest is mostly of the intense type.

ACKNOWLEDGMENTS

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THE PROTECTIVE EFFECT OF SOME INSECTICIDES AND CHEMICALS ON *TROGOXYLON IMPRESSUS* COM.

[*Coleoptera: Lyctidae*]

by H. NOUR and F. SIDAROUS

INTRODUCTION

Unfortunately, the presence of the Lyctid powder-post beetles in wood, is generally not discovered until the damage has advanced to a serious degree. It means little to discuss preventive measures then — money will have to be spent on control measures and repairs, and the amount will be high compared to what the protection would have costed. The purpose of this study, which has been carried out at the Entomological Section, Ministry of Agriculture, Dokki, Egypt, is to obtain information concerning the effectiveness of insecticides and chemical paints in protecting wood products from insect attacks.

TECHNIQUE

Series of tests were established in January, 1956, when various chemicals were applied as 3 minutes dips to boards of oak wood floor, 4 inches long, 1 inch thick and 1½ inch wide ; all boards were biologically tested. The dips were D.D.T., lindane, dieldrin, pentachlorophenol, toxaphene, creosote, paradichlorobenzene, chlordane; the solvent used for these chemicals was kerosene, also polyvinyl acetate solution 5% (plastic materials) and Markon 9 L.V. (plastic materials of low viscosity) were applied as 2 coats brushing.

Five samples were treated with each chemical formulation, a similar number of boards were treated with kerosene only and as control a like number was left untreated.

The treated samples were placed in the open air until their surfaces were dry. Then each board was placed in a jar provided with a gauze cover. Twenty adult beetles of *T. impressus* were liberated on each test sample during May and September,

1956, 1957 and 1958, and the beetles were removed from the jars right after death. Inspections have been made at intervals since the samples were first exposed to beetles' attack.

The following Table shows the formulations tested and the number of beetles emerged during the period of August, 1956, then at intervals of April and August of the following years.

Chemicals	Number of beetles emerged at intervals of						
	1956	1957		1958		1959	
	August	April	August	April	August	April	August
D.D.T. 5%	0	0	0	43	—	—	—
Lindane 0.5%	0	0	48	—	—	—	—
Dieldrin 0.5%	0	0	35	—	—	—	—
Pentachlorophenol 5%	0	0	0	0	0	69	—
Toxaphane 5%	67	—	—	—	—	—	—
Creosote 5%	0	62	—	—	—	—	—
Paradichlorobenzene 25%	71	—	—	—	—	—	—
Chlordane 2.5%	0	0	0	0	0	53	—
Polyvinyl Acetate	0	0	0	0	0	0	0
Solution 5%							
Markon 9 L.V.	0	0	0	0	0	0	
Law viscosity							
Kerosene	101	—	—	—	—	—	—
Untreated boards	98	152	72	101	95	115	

Emergence in April is the result of the September infestation of preceding year. Emergence in August is the result of May infestation of same year.

RESULTS

Examination of the Table reveals the following:

- (1) The solution of 5% pentachlorophenol and that of 2.5% of chlordane were both highly effective in protecting the wood for almost 33 months.
- (2) The solution of 5% D.D.T. had a protective effect for almost 21 months.
- (3) The protective effect of both the 0.5% lindane and the 0.5% dieldrin on wood lasted for almost 17 months.
- (4) There was no significant difference between the solutions: 5% toxaphene, 25% paradichlorobenzene, kerosene alone, and the untreated wood.
- (5) It was noticed that the polyvinyl acetate and markon 9 L.V. covered the boards with a film of plastic material. This plastic smooth layer caused the wood to

be unsuitable for egg laying further exposure of wood to beetles in being carried out periodically.

SUMMARY

(1) Brushing with solution of 5% polyvinyl acetate or Markon 9. L.V. protects the wood over 41 months, thus will be recommended for the treatment of high valuable wood articles.

(2) Dipping for three minutes in solution of 5% pentachlorophenol in kerosene or solution of 2.5% chlordane in kerosene gives limited protection and the treatment should be repeated after 33 months.

FIRST RECORD ON SOME PREDATOR MITES OF FAMILY CHEYLETIDAE IN EGYPT

[Acarina]

E. A. EL-BADRY

(with 2 Text-Figures and 1 Table)

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Mites of the family *Cheyletidae* are frequently found on vegetation and sometimes on milled wheat associated with Acarids. They are sluggish and their body is oval in shape and varies from yellow to reddish in colour. Members of this family undergo incomplete metamorphosis since they normally develop through larval and nymphal stages.

In 1912, EWING reported that young mites, *Cheyletus seminovus* Packard preferred to attack eggs of other mites such as *Acaridae* with which they were associated. He also found that this predator killed almost 95% of Acarids in the milled wheat samples examined. However, despite the fact that these mites were mainly found in association with infestation of *Acaridae*, *Tetranychidae* and scale insects, BAKER (1952) mentioned that they did not appear to be of great economic importance in controlling these pests. Although most members of this family are free living, yet BAKER added that some were found in bird feathers, in squirrel, rabbit or cat fur and some times they injured such hosts.

No information regarding any species of *Cheyletidae* have been previously recorded in Egypt. However, two species belonging to this family were reported for the first time, during a survey, carried out on red spider mites and their predator mites in 1958 and 1959 in Giza area. These two species were *Cheletogenes ornatus*

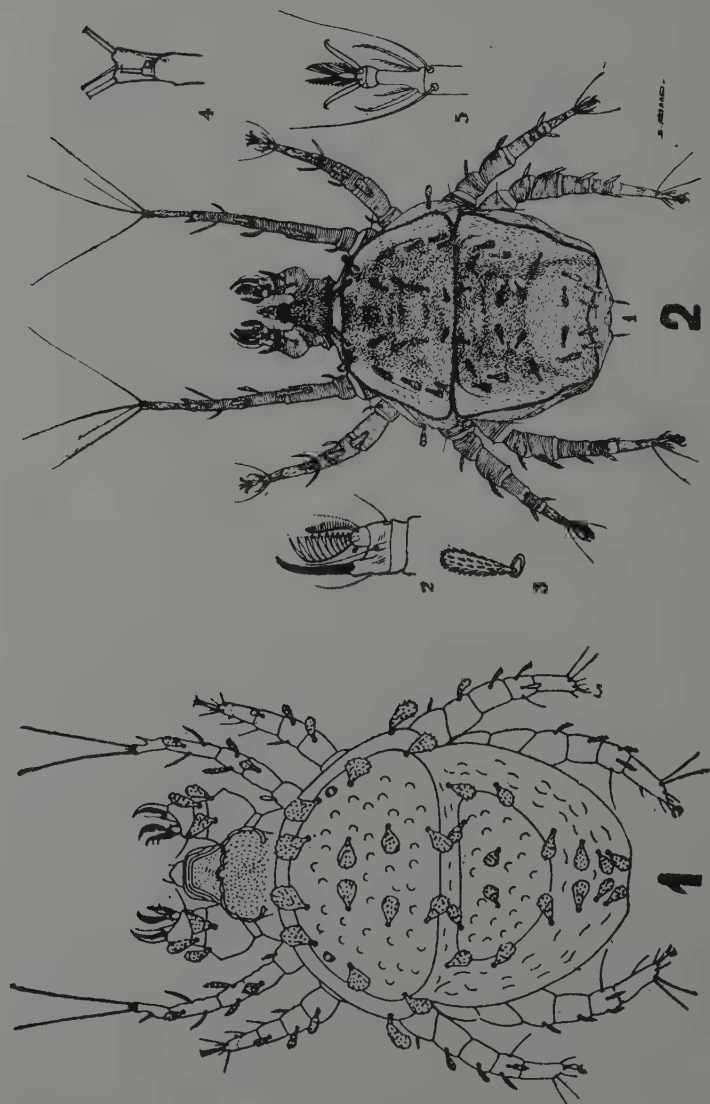


FIG. 1: *Cheletogenes ornatus* (C. and F.); Dorsum of female after Baker). — FIG. 2: *Eutogenes frater* Volgin; 1, Dorsum of female; 2, Pedipalp; 3, Body seta; 4, Tarsus I; 5, Tarsus II.

(C. and F.) and *Eutogenes frater* Volgin (Figs. 1 and 2). The latter, as communicated by E.W. Baker (personal communication), was recently described by VOLGIN (1958), in Russia, as a new species.

During the course of this investigation, leaf samples were taken on regular intervals of 10 days from fruit trees, truck crops and ornamentals located on the farm of Faculty of Agriculture, University of Cairo. Each sample included 50 leaves, collected at random, from each host. One square inch was examined per leaf according to the method described by YOUNG and GAINES (1954).

Examination of different samples showed that *Cheletogenes ornatus* was widely distributed on leaves and twigs of fruit trees associated with eggs of the spider mite *Brevipalpus* sp. Females layed yellow small eggs in groups of 3 to 5 covered with white thin webs. Feeding stages of this predator were sometimes seen attacking the host's eggs and sucking their contents. They usually aggregated on lower surfaces of leaves hiding beneath dead scales or dried crusts of honey dew. In such a nesting site, sometimes harboured 5 or more Cheyletids. It was also observed that this mite was slow in movement and always returned to its shelter when disturbed.

Seasonal incidence of this predator mite showed that no stages were found during winter, spring and the beginning of summer. However its population density increased comparatively in August and September (Table I). Few individuals were also found during June, October and November.

TABLE I

The monthly mean number of the predator mite Cheletogenes ornatus on fruit trees during 1958 and 1959.

	Mean number per 100 square inches of leaves											
	Plum		Edible fig		Pomegranate		Peach		Apricot		Quince	
	1958	1959	1958	1959	1958	1959	1958	1959	1958	1959	1958	1959
April . . .	—	—	—	—	—	—	—	—	—	—	—	—
May . . .	—	—	—	—	—	—	—	—	—	—	—	—
June . . .	—	—	—	—	—	—	—	—	—	—	—	—
July . . .	11	10	—	31	5	—	—	—	—	12	—	—
August . .	33	44	10	30	10	8	15	20	9	14	—	12
September	12	129	11	46	13	12	21	10	12	10	11	22
October . .	10	20	—	9	10	10	13	—	—	—	11	—
November .	9	—	—	—	—	—	—	—	—	—	—	—
December	5	—	—	—	—	—	—	—	—	—	—	—

It could be also noticed from the mentioned Table that population of this mite was found, in a descending order, on plum, edible fig, pomegranate, peach, apricot and quince.

The other mite, *Eutogenes frater*, was present in relatively small number on the ornamental plant, *Buddlia* sp. only, associated with eggs of the red spider mite, *Tetranychus cinnabarinus* (Bois.).

SUMMARY

Two predator mites *Cheletogenes ornatus* and *Eutogenes frater* were first recorded in Egypt. The former was found on fruit trees and the latter on *Buddlia* only. Population density of *Cheletogenes ornatus* increased comparatively in August and September.

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**STUDIES ON THE LONGEVITY
OF CARNIOLAN, CAUCASIAN AND ITALIAN
HONEYBEE WORKERS,
WITH SPECIAL REFERENCE
TO THEIR FORAGING BEHAVIOUR**

[*Hymenoptera: Apidae*]

(with 8 Text-Figures and 6 Tables)

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The aim of the present investigations was to study the longevity of the workers of the three standard races of honeybees (Carniolan, Caucasian and Italian), during the flowering seasons and during dearth. It was decided also to indicate the periods spent in carrying out hive duties and those spent in foraging by the workers of the three races. Statistical analyses were carried out to determine the relationships between the longevities and the hive-periods, the foraging periods and the brood-rearing rates.

It is known that long-lived bees are more profitable to their colonies. The benefit of long-lived bees to the colony, during the flowering seasons, lies either in rearing more brood or in foraging for a longer period. In winter months when no flowers are found and scarcely brood is reared, long-lived bees are of more value. Colonies of long-lived races can spare brood rearing during winter months, specially those in too cold regions, where the brood reared during winter is liable to die of cold. Their workers can maintain the colonies for longer periods without need of new workers to replace them.

The knowledge of the longevity of winter bees is also of great interest to beekeepers, specially in countries of moderate weather such as Egypt (U.A.R.) where brood is reared allover the year. If we know the mean longevity of workers

during winter, we can indicate the time of feeding the colonies, to increase brood-rearing, before they lose the majority of their workers. We can also feed the colonies at the suitable times before blooming seasons, so as to rear the largest number of bees, before the commencement of plant flowering, and thus to gather the greatest amount of nectar from flowers.

REVIEW OF LITERATURE

NELSON (1927) observed the duties performed by young bees, and noted that under the rather exceptional conditions under which he made his observations; i.e., with "unbalanced" colonies, bees as young as four days old, performed orientation flights. His observations revealed a considerable degree of shifting from one activity to another amongst workers between three and twelve days of age.

According to RIBBANDS (1953), ROSCH (1925-1930) showed that the division of labour is very largely based on the physiological age of the worker bees concerned. He noticed that, in the course of her life-time, each worker normally would perform successively each of these numerous tasks: (1) brood rearing when less than 12 days old; (2) secreting wax and building comb when 13 to 18 days old; (3) guarding the entrance at 18 to 20 days of age; (4) foraging after 21 days of emergence.

He also observed that deviations from this standard pattern can exist, and bees may perform any work when necessary to restore the balance of the colony, irrespective of her age.

HAYDAK (1937), in an experiment in which bees of known age were fed a pure carbohydrate diet for a period of 189 days had some of the bees living to 236 days of age, while experiments of MAURIZIO (1946) showed that feeding with a moderate amount of pollen supply lengthens the life, and supports the idea that the better pollen supply of bees emerging in late summer and fall is related to their longer life.

RIBBANDS (1952) stated that MOSKOVLJEVIC's investigations (1939) on the division of labour had shown that the expectation of working life of summer bees can be substantially increased if all the sealed brood is regularly removed from a colony, so that the same nurse bees continue with brood rearing indefinitely. In such circumstances summer lives of 72 days had been reported. Conversely, RIBBANDS (1950) showed that expectation of adult life of bees which commenced foraging at an early age was significantly less (30.1 ± 1.2 days) than that of those starting to forage later (37.1 ± 0.6 days), although the expectation of foraging life of the early foragers was greater (15 ± 1.2 days compared with 10.8 ± 0.8 days).

RIBBANDS noted also that the mean length of foraging life of 32 bees which commenced foraging when 11-22 days old was 14.4 ± 0.9 days, but among 15 bees (of the same age and living in the same colony) which commenced foraging when

24-32 days old, it was only 8.3 ± 0.6 days. In a second experiment 44 bees which commenced foraging when 9-22 days old had a mean foraging life of 17.2 ± 0.8 days, but 8 similar bees which commenced to forage when 28-35 days old had a mean foraging life of 7.2 ± 0.5 days.

EL-DEEB (1952) when working on the longevity of Italian, Caucasian, Carniolan and Golden Italian races of honeybees, found that the race that showed more activity in brood rearing and honey storing, during the active season, lived a shorter time than that of the other races which were less active. On the other hand, during the periods previous to and following the honeyflow, the life span was extended because of less strenuous activity, with all races occupying the same position relative to each other as during the honeyflow. His data shows that the average of longevity for the periods previous to the honeyflow, during the honeyflow, following the honeyflow, and during the winter were, respectively, for the Italians, 26.49, 20.78, 25.62, and 109.41 days; for the Caucasians, 27.56, 23.91, 29.19, and 82.27 days; for the Carniolans 29.45, 25.73, 32.80, and 71.65 days; and for the Golden Italians, - 32.58, 26.38, 32.93 and 71.25 days. He observed also that the colony whose workers lived longer produced less honey, and reared less brood than the others. It was found also that the strength of the colony had an influence on the longevity of the workers, without respect to the race, so the workers lived a shorter time in strong colonies than those in weaker ones.

LINDAUER (1953) confirmed ROSCH's findings about the segregation of work amongst bees in the colony. He noticed that the individual bee always performed several tasks during the same period: cell cleaning, with brood rearing and comb building, but this was not noticed in the case of foraging. These hive duties could be carried out, at least as casual work, for much longer than it had hitherto been thought possible. The existence of the physiological conditions necessary for this, was demonstrated by comparative histological investigations and direct observations, which also showed that the pharyngeal and wax-secreting glands could often function at the same time.

HASSANEIN and EL-BANBY (1955) found that the period spent by Egyptian honeybees, in hive work varied from 12 to 49 days, and the average length of this period was 22.07 ± 0.47 days. The foraging period was ranging from 1 to 35 days, and its average was 12.49 ± 0.47 days. The total life of the Egyptian honeybee was varying from 17 to 66 days, and the average longevity was 34.56 ± 0.64 days, during the flowering periods of the main crops in the district.

METHOD

In order to study the foraging behaviour of the individual adult honeybee at the entrance of the hive, it is necessary to mark each worker in such a way that it may be easily recognised with certainty and speed. In the present investigations

three colour spots were used in marking each individual, one on the thorax and two on the abdomen. The following six colours were found to be most readily distinguished: white, yellow, red, green, blue and pink. It was possible to mark 216 bees with different marks, by using this system of colour combinations, thus 72 bees of each race could be introduced and observed individually in one colony at a time. The colour paints used in marking the bees were quick-drying cellulose enamels. When necessary these paints were thinned down with acetone.

The experimental bees were obtained by keeping combs of sealed worker brood in an incubator at 33°C. and approximately 60% relative humidity, and as the adult bees emerged they were marked. The brood of each race was isolated in a certain wire cage so that the emerging bees of different races might not be mixed together. No anaesthetic was necessary when handling such young bees. After marking the bees of the three races, each by a certain colour pattern, they were put in a small wire cage, provided with a glass feeder, and immediately introduced into the experimental hive, to be liberated on the following day.

In each experiment, as soon as the marked bees had been introduced into their respective colonies, a daily watch was kept for two hours at the entrance of their hives, and the identity of each marked bee entering or leaving her hive was reported.

In this way it was possible to determine the approximate date on which each bee commenced foraging, and the approximate length of her foraging life. When she did not appear any more at the entrance of her hive, it was assumed that she had died. This assumption was ensured by perfect examinations in the experimental hives at the last period of observations.

These experiments were carried out during the flowering seasons of citrus, clover and cotton, in the years 1956 and 1957. During each season, three experimental colonies, each of a different race, were used. In each colony 72 Caucasian bees, 72 Italian bees, and 72 Carniolan bees were introduced to be observed simultaneously.

At the end of the cotton flowering season in 1956, it was decided to investigate the longevity of workers during dearth. For these investigations mass colouring was applied. All the bees of each race were marked by a certain colour spot on the thorax. These experiments were decided to be carried out all over the year, during each month, since September 1956, till August 1957. In each month three experimental colonies of different races were used, each containing marked bees of the three races. In winter, the living marked bees of each colony were counted just before sunset, every three days. During months of activity the counts were made every two days.

RESULTS

Table I and Figure 1 include the mean durations of periods spent in hive work. Table II and Figure 2 include the mean durations of the foraging periods,

TABLE I

The mean duration of periods spent in hive work, by the workers of the three races, during the three flowering seasons of 1956 and 1957 (in days)

Seasons	Races	Means \pm confidence limits at 5% level		
		1956	1957	Total
Citrus	Caucasian	12.48 \pm 0.6954	23.30 \pm 0.4232	18.01 \pm 0.7568
	Italian	14.15 \pm 0.6354	21.65 \pm 0.2960	18.59 \pm 0.5421
	Carniolan	16.16 \pm 0.6522	22.28 \pm 0.2887	19.55 \pm 0.4784
Clover	Caucasian	9.13 \pm 0.1752	11.15 \pm 0.2979	10.16 \pm 0.2164
	Italian	8.55 \pm 0.2672	10.60 \pm 0.3073	9.71 \pm 0.2448
	Carbiolan	7.16 \pm 0.1739	10.59 \pm 0.2311	8.94 \pm 0.2556
Cotton	Caucasian	9.12 \pm 0.3100	13.13 \pm 0.7966	10.53 \pm 0.4116
	Italian	8.83 \pm 0.2638	12.80 \pm 0.5842	10.59 \pm 0.3959
	Carniolan	9.46 \pm 0.2744	12.76 \pm 0.7726	10.46 \pm 0.3534

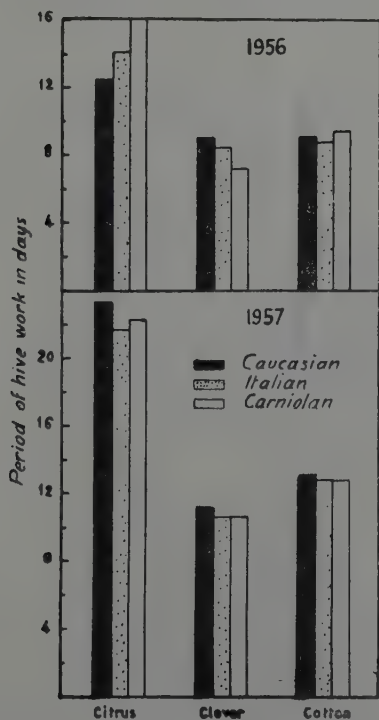


FIG. 1: The mean durations of periods spent by the workers of the three races in carrying out hive duties during the three flowering seasons.

TABLE II

The mean duration of foraging periods spent in field work, by the workers of the three races, during the main flowering periods of 1956 and 1957 (in days)

Seasons	Races	Means \pm confidence limits at 5% level		
		1956	1957	Total
Citrus	Caucasian	19.78 \pm 1.7852	12.33 \pm 0.7742	15.97 \pm 1.0553
	Italian	15.58 \pm 1.6590	13.10 \pm 1.0913	14.11 \pm 0.8649
	Carniolan	16.36 \pm 1.6721	12.12 \pm 0.8487	14.01 \pm 0.9077
Clover	Caucasian	7.54 \pm 0.6134	10.97 \pm 1.1488	9.29 \pm 0.6929
	Italian	6.40 \pm 0.6268	7.58 \pm 0.6882	7.07 \pm 0.4724
	Carniolan	6.37 \pm 0.5827	8.11 \pm 0.8985	7.28 \pm 0.5647
Cotton	Caucasian	12.69 \pm 0.6390	11.03 \pm 1.6746	12.11 \pm 0.7164
	Italian	11.83 \pm 0.3230	8.53 \pm 0.9326	10.36 \pm 0.6390
	Carniolan	10.91 \pm 0.7432	7.82 \pm 0.9986	9.98 \pm 0.6213

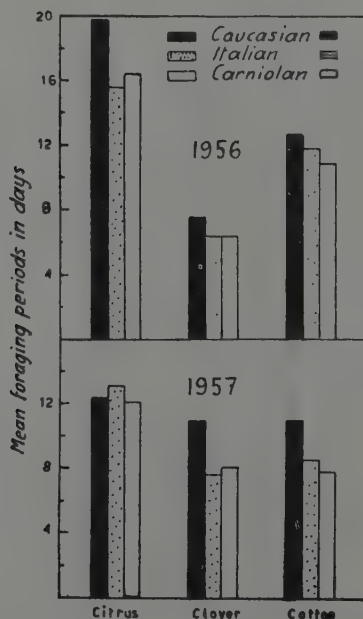


FIG. 2: The mean durations of periods spent in foraging by the workers of the three races during the three flowering seasons.

TABLE III

The mean longevity of the workers of the three races, during the main flowering seasons of 1956 and 1957 (in days).

Seasons	Races	Means \pm confidence limits at 5% level		
		1956	1957	Total
Citrus	Caucasian	32.26 \pm 1.9380	35.64 \pm 0.7564	33.99 \pm 1.0419
	Italian	29.72 \pm 1.5560	34.75 \pm 0.9484	32.70 \pm 0.8896
	Carniolan	32.52 \pm 1.4585	34.41 \pm 0.8628	33.56 \pm 0.8061
Clover	Caucasian	16.66 \pm 0.6386	22.13 \pm 1.1476	19.46 \pm 0.7450
	Italian	14.96 \pm 0.7072	18.17 \pm 0.6490	16.78 \pm 0.5178
	Carniolan	13.53 \pm 0.6087	18.70 \pm 0.8828	16.22 \pm 0.6256
Cotton	Caucasian	21.82 \pm 0.7901	24.16 \pm 1.7420	22.64 \pm 0.7789
	Italian	20.65 \pm 0.8748	21.34 \pm 0.9326	20.96 \pm 0.6241
	Carniolan	20.38 \pm 0.7764	20.58 \pm 0.9210	20.44 \pm 0.6070

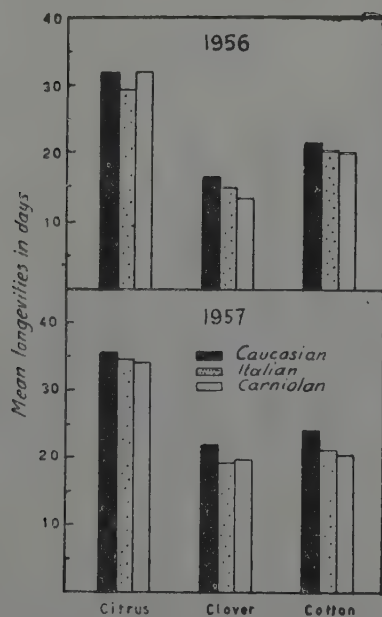


FIG. 3: The mean longevity of the three races during the three flowering seasons.

TABLE IV

The mean longevitys of the workers of the three races throughout the year (in days)

Months	Means \pm confidence limits at 5 % level		
	Caucasian	Italian	Carniolan
Sept. 1956	64.66 \pm 7.7489	29.59 \pm 2.5772	32.23 \pm 2.9551
Oct. 1956	51.32 \pm 4.9180	42.68 \pm 5.7313	47.32 \pm 3.4721
Nov. 1956	63.17 \pm 7.4300	58.62 \pm 3.1699	55.34 \pm 6.0956
Dec. 1956	51.51 \pm 3.0892	41.35 \pm 2.1056	50.86 \pm 2.6854
Jan. 1957	50.29 \pm 1.6540	33.48 \pm 1.8577	34.34 \pm 1.7893
Feb. 1957	47.96 \pm 1.7538	41.86 \pm 2.1146	38.25 \pm 1.9563
March 1957	37.16 \pm 1.0486	26.91 \pm 1.4190	29.07 \pm 1.2779
April 1957	23.22 \pm 0.8943	17.51 \pm 0.7556	17.90 \pm 0.7160
May 1957	14.47 \pm 0.6868	13.56 \pm 0.7201	14.11 \pm 0.6495
June 1957	21.65 \pm 1.3232	18.44 \pm 1.1731	20.52 \pm 1.3328
Aug. 1957	32.38 \pm 1.2724	28.06 \pm 1.1807	27.24 \pm 1.2863
Total	40.36 \pm 1.0425	32.69 \pm 0.8403	33.78 \pm 0.8630

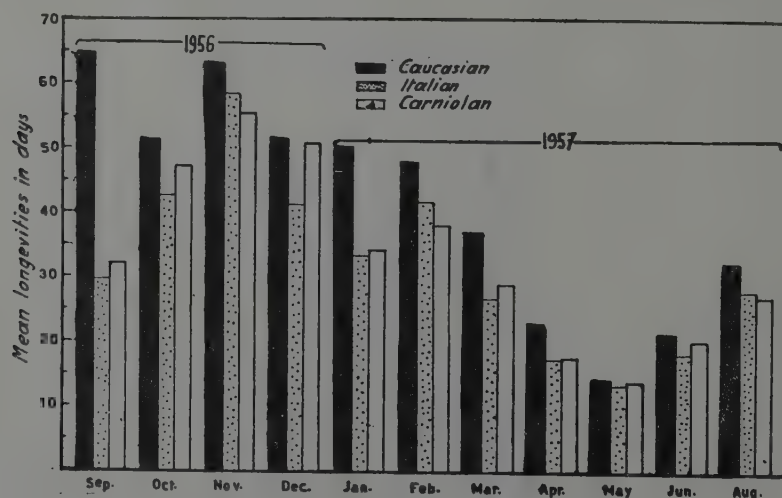


Fig. 4: The mean longevitys of workers of the three races during each month of the year.

and Table III and Figure 3 show the mean longevitys of the workers of the three races during the flowering seasons in the years 1956 and 1957. Table IV and Figure 4 include the mean longevitys of the mass marked workers during each

TABLE V

Correlation and regression coefficients between the daily brood-rearing rates in the colony and the mean periods of hive work; also between the mean duration of hive work (independent variable) and each of the mean foraging periods and the mean longevity of workers.

Independent variables	Dependent variables	Races	D.F.	Correlation coefficient	Level of significance percentage	Regression coefficient
Brood-rearing rate	Mean duration of hive work	Caucasian	14	-0.4364	10	-0.0131
		Italian	14	-0.5636	5	-0.0150
		Carniolan	14	-0.6015	2	-0.0185
Mean duration of hive work	Mean foraging period	Caucasian	14	0.1688	—	0.1428
		Italian	14	0.5421	5	0.4029
		Carniolan	14	0.5300	5	0.3672
Mean duration of hive work	Mean longevity	Caucasian	14	0.8070	1	1.1387
		Italian	14	0.9128	1	1.4016
		Carniolan	14	0.9188	1	1.3671

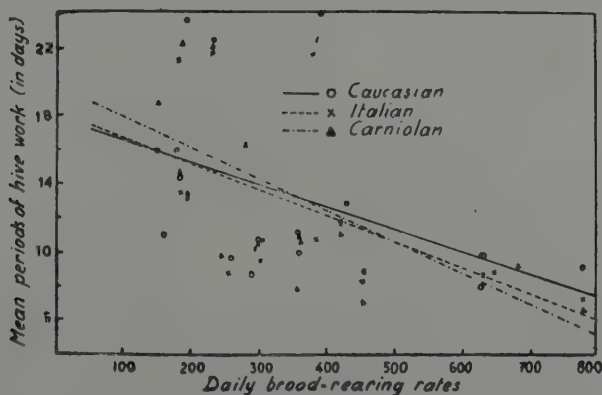


FIG. 5: Scatter diagrams and regression lines showing the relation between the daily brood-rearing rate in the colony and the mean periods spent in hive work.

month, since September 1956 till August 1957. (The results of July were excluded because the bees of this month were affected by insecticides used on cotton plants).

These records were statistically analysed to determine the longer-lived race, and that spends more days in brood-rearing or foraging.

The following results were found out from the analysis of variance Tables:

(1) There was no significant variation in the duration of periods spent in hive work

TABLE VI

Correlation and regression coefficients between the daily brood rearing rate in the colony (independent variable) and the mean longevity of workers of the three races (dependent variable) during winter months.

Races	D.F.	Correlation coefficient	Level of significance percentage	Regression coefficient
Caucasian	15	-0.732 ****	0.1	-0.3216
Italian	11	-0.659 **	2.0	-0.1903
Carniolan	16	-0.605 ***	1.0	-0.1938

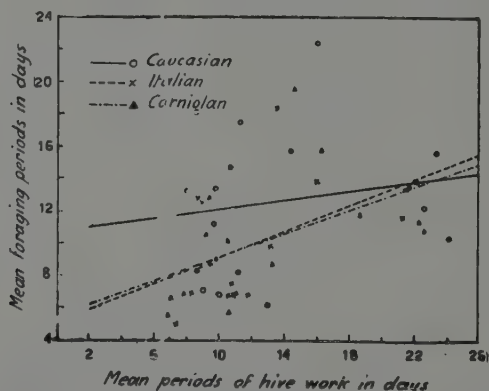


FIG. 6: Scatter diagram and regression lines showing the relation between the mean periods spent in hive work, and the mean periods spent in foraging.

by workers of different races, and that these periods varied with high significance from season to season and from year to year. It seems that this variance is found according to the amount of brood reared in the colony and to nectar income which encourage bees for foraging at an earlier age. The interactions; races X seasons, and seasons X years were also significant according to the variations in the activities of the respective colonies at different times.

(2) There were highly significant variations between the durations of foraging periods of workers according to the respective colonies (blocks), races, flowering seasons and years. The interactions; races X years, seasons X years, and races X seasons X years were also significant.

(3) The variations between the longevity of workers during the flowering periods, were highly significant according to the colonies into which they were introduced (blocks), races, seasons, and years.

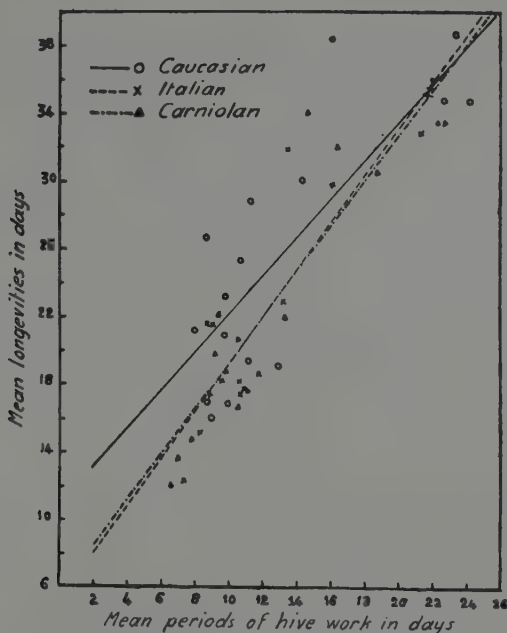


FIG. 7: Scatter diagrams and regression lines showing the relation between the mean periods spent in hive work, and the mean longevity.

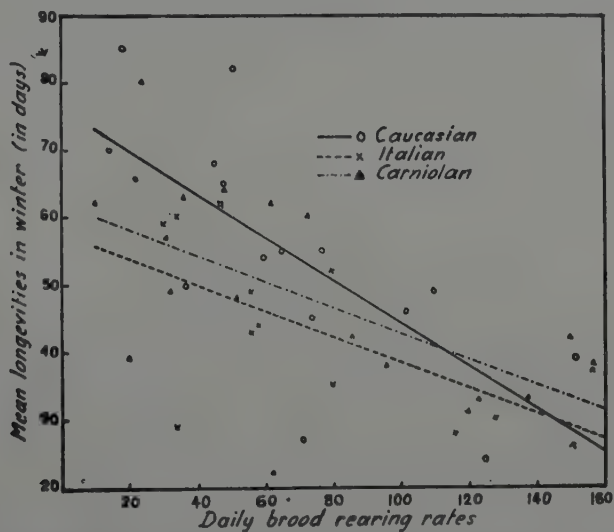


FIG. 8: Scatter diagrams and regression lines showing the relation between the daily brood rearing rates in the colony, during winter, and the mean longevity.

(4) The longevities of workers were greatly affected by the state of the colonies into which they had been introduced, and there were highly significant variations in the longevities of workers of different races, during different months.

It was observed also that the mean periods spent by workers in carrying out hive duties related largely to the amount of brood reared in the colony at the meantime, and that the mean foraging period and the mean longevities are related to the mean periods of hive work. So, it was decided to calculate the partial correlations between these variates in the different races.

Table V includes the correlation and regression coefficients of the daily brood-rearing rates in the colonies X the mean periods of hive-work, the mean durations of hive work X the mean foraging periods, and the mean durations of hive work X the mean longevities of Caucasian, Italian and Carniolan bees.

Figure 5 shows the scatter diagram and regression lines showing the relationship between the daily brood rearing rates in the colonies and the mean durations of the periods spent in hive work by Caucasian, Italian and Carniolan workers.

Figure 6 shows the scatter diagram and regression lines showing the relationship between the durations of hive work and the mean foraging periods of the workers of the three races.

Figure 7 contains the scatter diagram and regression lines showing the relationship between the mean durations of hive work and the mean longevities of different workers.

The longevity of workers in winter and dearth depends largely on the amount of brood reared in the colony, as there are no foraging activities at the time. Table IV and Figure 8 show the relationship between the daily brood rearing rates in the colonies and the longevities of the different worker races living within, during this period.

CONCLUSIONS

(1) The variance in the periods spent by workers of different races in hive work.

It is recognised that there was no significant difference between the durations of the periods spent in carrying out hive duties by different races of bees. These periods varied with high significance according to the different seasons and years.

Bees of the different races spent more days in hive work, during the flowering season of citrus, than during the clover and cotton blooming seasons in the year 1956 and 1957. The periods after which they commenced foraging were longer during the blooming period of cotton than during the blooming period of clover. These periods were longer in the blooming seasons of the years 1957 than they were in 1956.

The mean durations of periods spent by the Caucasian bees in carrying out hive duties in the years 1956 and 1957 were, successively, 12.48 and 23.30 days during the citrus blooming seasons, 9.13 and 11.15 days during the blooming periods of clover, and 9.12 and 13.13 days during the flowering seasons of cotton.

The mean durations of periods spent by the Italian bees in carrying out hive duties in the two years were, respectively, 14.15 and 21.65 days during the blooming seasons of citrus, 8.55 and 10.60 days during the blooming seasons of clover, and 8.83 and 12.80 days during the blooming seasons of cotton.

The mean durations of periods spent by the Carniolan bees in carrying out hive duties in the two years were, successively, 16.16 and 22.28 days during the blooming seasons of citrus, 7.16 and 10.59 days during the blooming seasons of clover, and 9.46 and 12.76 days during the blooming seasons of cotton.

(2) The relationship between the daily brood-rearing rates and the mean periods of hive work

It is apparent that there is a high significant negative correlation between the daily brood rearing rates in the colonies, and the means of the periods spent in hive work within these colonies as shown in Table V and Figure 5. It is obviously noticed from these correlations that the increase in brood-rearing increases the adult workers in the colony, and this increase induces the older bees to forage at an earlier age. The amount of brood reared in the colonies during different flowering seasons, is obviously related to nectar income. So, foraging at earlier ages during clover, then cotton flowering periods, than during citrus seasons, may be indirectly related to the excess of the nectar income, from the first mentioned crop then the second than the latter.

The levels of significance of the correlation coefficients between the daily brood rearing rates, and the mean durations of hive work, differ in the three races.

The correlation coefficient that exists between the daily brood rearing rates and the mean durations of hive work of the Caucasian bees was -0.4364, and the regression of the mean period of hive work on the daily brood rearing rates was 0.0131 day per one worker reared. This means theoretically that the average period spent in hive work by Caucasian workers is decreased by 0.0131 day for every extra larva fed over the average brood reared daily.

For the Italian bees, the correlation coefficient was -0.5636 and the regression was -0.0150 day per one bee reared daily in the colony.

For the Carniolan bees, the correlation coefficient was -0.6015 and the regression was -0.0185 day per one brood reared daily.

(3) The variance in foraging periods of different races

It was found that the means of the foraging periods of the Caucasian bees were almost always significantly longer than the Italians and the Carniolans. The differences between those periods of the Italians and Carniolans were insignificant.

Bees of the different races spent significantly more days in foraging during the flowering seasons of citrus in the two years, than during the other flowering seasons. This prolonged duration is largely correlated with the longer periods spent in hive work during this season, the less brood reared daily at the time, and also the less daily expeditions flown in this period. The variance in the foraging periods during the other two seasons were not significant.

The mean duration of the foraging periods of the Italian workers in the two years were, successively, 15.58 and 13.10 days in the flowering seasons of citrus trees, 6.40 and 7.58 days in the blooming periods of clover, and 11.83 and 8.53 days in the flowering seasons of cotton.

The means of the foraging periods of Carniolan bees in the two years were, successively, 16.36 and 12.12 days, when foraging on citrus flowers, 6.37 and 8.11 days when foraging on clover blooms, and 10.91 and 7.82 days when foraging on cotton flowers.

The mean periods spent in foraging by the Caucasian bees in the years 1956 and 1957 were, successively, 19.78 and 12.33 days during the citrus blooming seasons, 7.54 and 10.97 days during the blooming seasons of clover, and 12.69 and 11.03 days during the blooming seasons of cotton.

(4) The longevity of workers of different races during the flowering seasons

It is clearly shown that the Caucasian workers were almost always longer lived than the others. The mean longevities of the Caucasian workers significantly exceeded the mean longevities of the others during the flowering seasons of clover and cotton, while the differences during the citrus blooming seasons were insignificant. There was no significant difference between the longevities of the Italian and Carniolan workers during the different seasons.

It was noticed also that the bees of the different races lived longer during the blooming seasons of citrus trees in the two years. This prolongation in longevity seems to be a result of less effort spent in brood rearing or foraging during this period.

The longevities during the flowering periods of cotton were significantly shorter than the longevities of the workers of the same races during the citrus blooming seasons in the two years. The longevities of the different workers were too short when foraging on clover blooms. The differences in the longevities of the workers of each race during the different seasons were always significant.

The longevities of the workers of the different races were increased in the year 1957 than they were in the year 1956. This increase in life may be related to the retard in commencing foraging during 1957.

The mean longevities of the Caucasian workers in the years 1956 and 1957 were, successively, 32.26 and 35.64 days during the blooming seasons of citrus trees, 16.66 and 22.13 days during the blooming seasons of clover, and 21.82 and 24.16 days during the blooming seasons of cotton.

The mean longevitys of the Italian workers in the two years were, successively, 29.72 and 34.75 days when foraging on citrus flowers, 14.96 and 18.17 days when foraging on clover flowers, and 20.65 and 21.34 days when foraging on cotton flowers.

The mean longevitys of the Carniolan workers in the two years were, successively, 32.52 and 34.41 days during the flowering periods of citrus, 13.53 and 18.70 days during the flowering periods of clover, and 20.38 and 20.58 days during the flowering periods of cotton.

(5) The relationship between the average periods spent in hive work, the average foraging periods and the average longevitys

It was noticed from the formerly mentioned results that the workers of the different races spent long time in hive work during the blooming seasons of citrus trees, and lived long. They spent less time in hivework during the blooming seasons of cotton and thus were shorter lived. They commenced foraging early on clover flowers and lived for few days. The workers of the different races commenced foraging at later ages during all the blooming seasons of the year 1957, than their ages when foraging during the flowering seasons of the same plant species in the year 1956, and they lived for longer periods in the second year.

It can be concluded from these results that the longevitys of the workers during the flowering seasons are largely related to the duration of periods spent in hive work. Data given in Table V shows that there is a very high positive significant correlation between the mean duration of hive work, and the mean longevity of the workers. The correlation coefficients between these two varieties were significant at 0.1% level in the case of all the races.

The correlation coefficient that exists between the mean periods spent in hive work and the mean longevity of the Caucasian workers was 0.8070, and the regression coefficient was 1.1387. This means that the mean longevity of the Caucasian workers was increased by 1.1387 days for every extra day spent in the hive over the average period of hive work.

For the Italian bees, the correlation coefficient was 0.9128 and the regression coefficient was 1.4016 days of increase in longevity per each one day spent in the hive work.

For the Carniolans, the correlation coefficient was 0.9188, and the regression coefficient was 1.3671 days of longevity for each extra day of hive work.

The value of the correlation and regression coefficients between the mean period of hive work and the mean foraging period were also calculated. The correlation between these two varieties was positive and significant at 5% level in the case of the Italian and Carniolan bees, but it was insignificant in the case of the Caucasians.

The regression of the mean foraging period on the mean duration of hive work is small in the case of the three races, if compared by the regression of the

mean longevity on the mean period of hive work. In the case of Caucasian workers, the regression coefficients was 0.1428 day of increase in foraging period per each extra day spent in hive work. In the case of Italian bees, the regression coefficient was 0.4029 day of foraging per every extra day spent in hive work. In the case of the Carniolans the regression coefficient was 0.3672 day of foraging per every extra day of hive work.

It can be understood from the above mentioned correlation and regression coefficients that the crops which yield more nectar induce egg-laying, which causes the increase in the number of workers in the colony, and thus the older bees commence foraging at earlier ages. The bees which carry out field work at an early age seem to forage for a slightly less period than bees which commence foraging at later ages, but the expectation of their total adult life is sharply less than that of those starting to forage later.

It can also be concluded that bees which are obliged on foraging early, according to the increase in the daily emerging workers, are short lived, and this means that the hive work is less exhaustive and needs less effort than field work. Foraging seems to be a strenuous work specially for young bees. According to these results it seems that the conclusions both of MOSKOVLEVIC (1939), which show that the expectation of working life of summer bees is increased if they continue with brood rearing indefinitely, and RIBBANDS (1950), which show that the longevities of workers are decreased by foraging at earlier ages, are not controversial with each other.

(6) The longevities of the workers during the different months.

It is realised from Table IV and Figure 4 that the Caucasian workers were the longest-lived bees allover the year. The differences between the mean longevities of the workers of the Caucasian race and those of the Italian and Carniolan races, were almost always significant during all the months, while there was no significant differences between the longevities of the Italian and the Carniolan workers.

The workers of the three races which had emerged in November showed the maximal longevities, then the lives of bees emerging in the following months decreased gradually by the increase of activity according to the flowering of the broad bean, during December and January. The longevities decreased speedily since March according to the blooming of the citrus and ornamental trees. In May the bees lived for too short periods owing to their foraging activity on clover flowers. In June the activity of bees began to decrease according to the fall of clover blooms and the beginning of cotton flowering, thus their longevities increased. The majority of bees emerging in July were lost by the effect of pest control thus the results of this month were excluded. Then the longevities of the workers increased gradually, and so on.

The longevitys of the Caucasian, Italian and Carniolan bees were, respectively, 64.66, 29.59 and 32.23 days in September 1956, 51.32, 42.68 and 47.32 days in October 1956, 63.17, 58.62 and 55.34 days in November 1956, 51.51, 41.35 and 50.86 days in December 1956, 50.29, 33.48 and 34.34 days in January 1957, 47.96, 41.86, and 38.25 days in February 1957, 37.16, 26.91 and 29.07 days in March 1957, 23.22, 17.51 and 17.90 days in April 1957, 14.47, 13.56 and 14.11 days in May 1957, 21.65, 18.44 and 20.52 days in June 1957, 32.38, 28.06 and 27.24 days in August 1957.

(7) The relationship between the brood rearing rates in the colonies during months of dearth, and the mean longevitys of the workers living within them.

It was observed that bees lived longer in weak colonies than in strong colonies. During winter and months of dearth, the bees reached the maximal age, when they had no work to do unless rearing the few brood found at that time. The bees of the different races which were living in colonies rearing less brood, were longer lived than those living in colonies rearing more brood.

It is apparent from the data given in Table VI and Figure 8, that there is a highly significant negative correlation between the daily brood rearing rates in the colonies, and the mean longevitys of workers living within them. The levels of significance of the correlation coefficients between the daily brood rearing rates, and the mean longevitys of the workers, differ in the case of the three races.

The correlation coefficient that exists between the daily brood rearing rates and the mean longevitys of the Caucasian bees was -0.732 which was significant at 0.1% level, and the regression was -0.3216 day in longevity per each extra brood reared daily. This means theoretically that the average longevity of Caucasian workers living in a colony decreases by 0.3216 day for every extra larva fed over the average brood reared daily.

The correlation coefficient for the Italian bees, was -0.659 (significant at 2% level), and the regression coefficient was -0.1903.

The correlation coefficient for the Carniolan bees was -0.605 (significant at 1% level), and the regression coefficient was -0.1938.

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A TAXONOMIC REVIEW OF CERTAIN SPECIES IN THE GENUS *CHIROTHRIPS* HALIDAY

[*Thysanoptera: Thripidae*]

(with 16 Text-Figures)

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INTRODUCTION

The genus *Chirothrips* was originally described by A.H. HALIDAY (1936); since that time many species have been described from many different parts of the world. This genus includes about fifty-three known species, fifteen of which have been recorded from the United States, and only seven from California. In 1939 FLOYD ANDRE published a synopsis of the American species of *Chirothrips* known then, and no other work has been done in this genus. The lack of workers on this group is probably due to the extra steps which are necessary to take before identifying or studying any specimen.

Within the population representing the species covered in this paper, namely *manicatus*, there existed such variation in color, position of the setae on the vertex, size, and especially the lateral length of the head process in front of the eyes that the key of ANDRE (1938) had to be modified.

The following paper is a preliminary discussion of a few species, with a key to the females and another for the males. A selected bibliography and a list of the species of the world are included. The writer hopes that this paper will be of help to the future workers in this group.

BIOLOGY

Very little is known about the biology of this genus. In Europe HUKKINEN (1936) found that *Chirothrips hamatus* Tryb. injured meadow foxtail grass to the

extent of 25% in 1932 and 3% in 1934. In 1948 Dr. S.F. BAILEY, at the University of California, realized the importance of *Ch. aculeatus* and published the following informations:

Ch. aculeatus Bagn. frequently breeds up in very large numbers in California in late winter and early spring. It's principal host is foxtail grass, *Hordeum murinam* L., but it has been taken from other incidental hosts such as tomato, pear, fig and various weeds. Aside from its chief host, it is numerous on wild oats, barley and wheat. Dr. BAILEY has recorded other species on grains and grasses in the western states, namely *Ch. manicatus* Hal., *Ch. mexicanus* Crawford. He has also found that oats, if grown in small acreage, frequently support heavy infestations of *Chirothrips* which produce the typical blasting of the leaves and spikelet. No chemical control has been used, but early harvest has been suggested for the control of the species involved.

CHIROTHRIPS Haliday

Thrips (Chirothrips) Haliday, 1836, *Entom. Mag.*, III, p. 444.

Type species: *Chirothrips manicata* Haliday (*loc. cit.*).

Small thrips (0.7-1.5 mm). Color ranges from brownish-yellow to blackish-brown; tarsi and third antennal segment usually lighter. Head very small and produced in front of eyes into a three-cornered process upon which the antennae are situated. Ocelli present in the females and located far back; wanting in the males. Antennae eight segmented. Maxillary palpi three-segmented. Prothorax trapezoidal in form. Legs short and the fore pair extremely thickened. Wings long and very slender; front fringe well developed. Males wingless.

Chirothrips is closely related to the genus *Limothrips*. The triangular head process in front of eyes, the presence of two longitudinal veins in fore wings and the clearly eight-segmented antennae separate these two genera from all the others in the family Thripidae. *Chirothrips* is easily separated from *Limothrips* by the very small head which is usually about half the length of prothorax; in *Limothrips* they are almost of the same length.

KEY TO THE SPECIES OF *CHIROTHRIPS* IN THE COLLECTION OF THE UNIVERSITY OF CALIFORNIA AT DAVIS (1)

Females (wings present)

1. First antennal segment greatly enlarged; basal width of head only slightly more than twice greatest width of first segment of antenna..... 7
- First antennal segment not greatly enlarged; basal width of head about three times or more greatest width of first segment of antenna..... 2

(1) *hamatus* Tryb., *hoodi* Jacot Guill., *ammophila* Bagn., *fulvus* Moulton, *patruelis* Hood, *pallidicornis* Priesner are excluded.

2. Second antennal segment simple or enlarged gradually distally; outer angle broadly rounded, not drawn out into a pointed process..... 3
Second antennal segment greatly enlarged distally; outer angle drawn out into a prominent, usually somewhat pointed process..... 4
3. Second antennal segment simple, not at all enlarged distally; fourth antennal segment with forked sense cone.....*secalis* Moulton
Second antennal segment enlarged gradually distally, with outer angle broadly rounded; fourth antennal segment with simple sense cone...*falsus* Priesner
4. Head greatly produced in front of eyes; distance from anterior margin of eye to base of antenna about equal to length of cheek.....*frontalis* Williams
Head much less prominently produced in front of eyes; distance from anterior margin of eye to base of antenna not more than half length of cheek.... '5
5. Head distinctly produced in front of eyes; distance from anterior margin of eye to base of antenna equal to about half length of cheek ..*productus* Hood
Head very slightly produced in front of eyes; distance from anterior margin of eye to base of antenna less than half length of cheeks..... 6
6. Process at tip of second antennal segment without a strictly terminal setae; lateral side of praeocular process arched; setae at posterior margin of pronotum 40-60.....*aculeatus* Bagnall
Process at tip of second antennal segment with a strictly terminal seta; lateral side of praeocular process straight, not arched; setae at posterior margin of pronotum 30-40 long*manicatus* (Haliday)
7. Posterior pair of setae on vertex placed behind, opposite or only very slightly in advance of median ocellus, opposite or behind middle of eyes..... 9
Posterior pair of setae on vertex placed far in front of median ocellus, opposite anterior third of eyes 8
8. Vertex of head usually with seven or eight pair of setae; each posterior angle of pronotum with one prominent spine.....*spiniceps* Hood
Vertex of head with not more than three or four pair of setae; each posterior angle of pronotum with two prominent spines.....*mexicanus* Crawford
9. Vertex of head with five or six pair of stout setae.....*crenulatus* Hood
Vertex of head with about thirty-six to forty-four pair of setae *texasus* Andre

Males (wings absent)

1. First antennal segment greatly enlarged; basal width of head only slightly more than twice greatest width of first antennal segment. Fully mature individuals yellow to light brown..... 5
First antennal segment not greatly enlarged; basal width of head about three times greatest width of first antennal segment. Fully mature individuals brown to blackish-brown. 2

2. Second antennal segment simple or enlarged gradually distally; outer angle broadly rounded, not drawn out into a pointed process..... 3
 Second antennal segment greatly enlarged distally; outer angle drawn out into a prominent pointed process.....*manicatus* (Haliday)
3. Second antennal segment barrel-shaped; outer angle not drawn into a pointed process*secalis* Moulton
 Second antennal segment enlarged gradually distally 4
4. Head very slightly produced in front of eyes; distance from base of antenna to front margin of eyes less than half the length of cheek*aculeatus* Bagnall
 Head moderately produced in front of eyes; distance from base of antenna to front margin of eyes about half the length of cheek.... *falsus* Priesner
5. Vertex of head with seven or eight pairs of setae; posterior angles of pronotum each with one prominently developed spine..... *spiniceps* Hood
 Vertex of head with only three pairs of setae; angles of pronotum each with two prominent spines*mexicanus* Crawford

***Chirothrips aculeatus* Bagnall**

(Figs. 1-2)

1926. *Ch. similis* Priesner (nec Bagnall), Die Thysanopteren Europas, Pt. 1, p. 142.

1927. *Ch. aculeatus* Bagnall, Ann. Mag. Nat. Hist., Ser. 9, XIX, p. 567.

1938. *Ch. aculeatus* Bagnall, Andre, Proc. Ent. Soc. Wash., XLI (6), p. 196.

FEMALE (macropterous). — Length 1.55 mm. Color uniform brown; all tarsi yellow.

Head slightly longer than wide, vertex with three pair of setae, the lateral pair situated in the head process, the posterior pair very slightly in advance of the anterior margin of the median ocellus; head moderately produced; lateral margin of process noticeably arched; distance from anterior margin of eyes to base of antenna about 0.013 mm; length of cheek 0.032 mm.; eyes black, about half as long as head.

Prothorax a little more than one and a half as long as head, about 1.25 wider than long; surface with few scattered setae of same size of those in the head; posterior part with distinct dark sculpture, outer spine on posterior angle of prothorax 0.045 mm, inner spine 0.036 mm. Pterothorax almost as wide as prothorax.

Abdomen normal, a little wider than prothorax, posterior margins of segment I-VIII dentate, last abdominal segment very long, 0.096 mm, spines of which are 0.096 mm; segment IX, length about 0.058 mm, inner pair of spines 0.095 mm, outer pair about 0.120 mm.

Measurements (in mm.): Length 1.55; head, length 0.1280; greatest width 0.115; lateral length of head process 0.013; length of cheek 0.032; length of eyes 0.062; prothorax, length 0.20, greatest width 0.250; pterothorax, greatest width 0.31; fore wing, length 0.85, width at middle 0.03; abdomen greatest width 0.337.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.0195	0.0320	0.0352	0.0300	0.0300	0.0380	0.0090	0.0060
width	0.0320	0.0360	0.0240	0.0231	0.0210	0.0195	0.0050	0.0040

Total length of antenna 0.215 mm.

MALE (brachypterous). — Length 1.01 mm. Color uniform brown; all tarsi and third antennal segments paler.

Head about as long as wide, very little produced in front of eyes, lateral process in front of eyes abruptly rounded. Ocelli wanting, second antennal segment much less produced.

Prothorax a little longer than wide and subquadrate in shape.

Measurements (in mm.): Length 1.01; head, length 0.09, width 0.096; length of cheek 0.023; lateral length of head process 0.004; pronotum median length 0.162, greatest width 0.152; pterothorax greatest width 0.181; abdomen greatest width 0.24.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.0138	0.0250	0.0224	0.0288	0.0192	0.0300	0.0060	0.0050
width	0.0270	0.0224	0.0192	0.0224	0.0170	0.0160	0.0050	0.0030

Total length of antenna 0.140 mm.

Redescribed from the following material:

California: Auburn, April 27, 1939, sweeping grass by BAILEY and ANDRE, one female; Mt. St. Helena, June 9, 1936, sweeping grass, S.F. BAILEY, one female; Sequoia Pk., June, 1950, BECHTEL, one female; Mendocino, Co., Philo, July 19, 1949, grass, BAILEY, one female and one male; Clear Lake, May 14, 1949, sweeping grass on ditch bank, S.F. BAILEY, two males

Due to the fact that the original description of *Ch. similis* Bagnall was inadequate to determine the species accurately, PRIESNER redescribed as *similis* Bagnall the species which BAGNALL later (1927) found to be different from *similis* Bagnall and described as *aculeatus*. The original *similis* Bagnall was found later to be *Ch. manicatus*. In 1939 ANDRE redescribed the male of *aculeatus* from a specimen collected at Davis, California, on wheat heads in June 8 and at Gilroy on tomato, July 14, 1936, by S. F. BAILEY.

DISTRIBUTION: California, Oregon, England, Austria, Hungary, Italy and Spain.

HOSTS: *Lamium purpureum*, *Bromus tectorum* and other grasses.

Ch. aculeatus is close to *Ch. manicatus*, but it is separated from it by the arched lateral margin of the praecocular process and the lack of a small terminal bristle at the extreme end of the apex of the second antennal segment.

Chirothrips crenulatus Hood

(Fig. 10)

1927. *Ch. crenulatus* Hood, *Jour. N.Y. Ent. Soc.*, XXXIV, p. 130.

FEMALE (macropterous). — Length 1.30 mm. Color of abdomen, tarsi and apex of second antennal segments yellowish-brown, rest of the body brown, eyes dark black.

Head almost as long as wide, five or six pairs of stout setae on vertex, the posterior pair in line with the anterior margin of the median ocellus; distance from anterior margin of eyes to base of antenna about one-half the length of cheeks. Ocelli subequal. Antenna about 1.7 times as long as head; segment I enlarged and swollen; segment II inverted shoe-shaped with distinct sense cone on extreme apex of outer angle.

Prothorax 1.5 as long as head and 1.3 as wide as long; surface with scattered setae and with two pairs of short spines at the posterior angles of prothorax.

Abdomen a little narrower than pterothorax; posterior edges of abdominal sternites bare; lateral spines of segment X about 0.090 mm.

Measurements (in mm.): Length 1.3; head, length 0.016, greatest width 0.105; length of cheeks 0.017, lateral length of head process in front of eyes 0.009; pronotum, length 0.190, greatest width 0.230; mesothorax greatest width 0.297; abdomen greatest width 0.301.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.022	—	0.030	0.032	0.025	0.033	0.012	0.009
width	0.044	—	0.025	0.029	0.022	0.019	0.006	0.004

Total length 0.192 mm.

No male available for study.

Redescribed from one female, Colorado, Estes Park, July 31, 1938, sweeping grass, S.F. BAILEY.

The original description was based on four females as listed below:

Colorado: Boulder (Flagstaff Mt.), June 28, 1924, L.O. JACKSON, 1 female (holotype); Denver, June 21, 1918, sweeping L.O. JACKSON, 1 female; "Colorado", 1916, sweeping, L.O. JACKSON, 1 female; Nebraska (Lincoln), July 1, 1890, in room, LAWRENCE BRUNER, 1 female.

DISTRIBUTION: Colorado, Nebraska.

HOST: Various grasses.

This species is close to *mexicanus* and *spiniceps* but it is easily separated from the first by the number and situation of the setae on the vertex and from *spiniceps* by having two spines at each posterior angle of the prothorax.

***Chirothrips falsus* Priesner**

(Figs. 12-13)

1925. *Ch. falsus* Priesner, *Zool. Jahrb.*, L, p. 312.1927. *Ch. simplex* Hood, *Jour. N.Y. Ent. Soc.*, XXXV, pp. 128-130.

FEMALE (macropterous). — Color, blackish-brown, thorax tinged with orange subhypodermal pigmentation; tarsi and third antennal segment usually yellowish; forewings blackish brown, paler just beyond base; hind wings slightly darkened basally, remainder clear.

Head almost as long as wide; cheeks straight, about one-fifth as long as head and slightly more than one-third as long as eyes; the distance from anterior margin of eyes to front of head about equal to length of cheeks; two pairs of minute setae near base of antennae in addition to a prominent pair situated close to eyes and far in front of anterior ocellus. Ocelli subequal, the posterior pair opposite posterior margin of eyes. Antennae about 1.7 times as long as head; segment I a little enlarged; segment II with apical angles a little prolonged but broadly rounded without sense cone on outer surface of apex.

Thorax sides straight; pronotum with scattered minute setae; two prominent dark spines at posterior angles of prothorax.

Abdomen broader than pterothorax; tergites with posterior margin dentate.

Measurements (in mm.): Length 1.12; head, length 0.1120, width 0.1440; cheeks, length 0.0224; prothorax, length 0.2025, width 0.2700; abdomen width 0.3375.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.0192	0.0320	0.0288	0.0352	0.0288	0.0384	0.0128	0.0054
width	0.0352	0.0320	0.0256	0.0256	0.0224	0.0192	0.0064	0.0064

Total length of antenna 0.2080 mm.

MALE (brachypterous). — Length about 1 mm. Color dark brown; tarsi and third antennal segment yellowish.

Head with its total median length slightly less than the greatest width which is across cheeks. Ocelli wanting. Antenna much as in female; first antennal segment not greatly enlarged; spines at posterior angles of prothorax about 0.022 mm.

Measurements (in mm.): Length about 1; head, length 0.090, greatest width 0.102; lateral length of head process in front of eyes 0.009; length of cheek 0.021; pronotum, length 0.163, greatest width 0.188.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.016	0.022	0.021	0.027	0.017	0.029	0.009	0.006
width	0.032	0.027	0.023	0.026	0.021	0.018	0.005	0.004

Total length 0.165 mm.

Redescribed from the following material:

Arizona: Grand Canyon, June 17, 1949, on Brome grass, S.F. BAILEY, 3 females; Winslow, June 18, 1949, grass, S.F. BAILEY, 2 females; Grand Canyon.

June 1949, on Brome grass, 2 females; Flagstaff, June 15, 1949, sweeping, S.F. BAILEY, 2 females. — New Mexico: Albuquerque, May 20, 1949, sweeping grass, S.F. BAILEY, 5 females; Grants, June 18, 1949, sweeping grass, S.F. BAILEY, 6 females. — Utah: Green River, August 10, 1947, G.F. KNOWLTON, 1 female. — California: Bijou, Lake Tahoe, August 25, 1950, sweeping grass, S.F. BAILEY, 2 males. — Wyoming: Cheyenne, June 21, 1949, sweeping grass, S.F. BAILEY, 6 females.

PRIESNER described *falsus* from females collected in Mexico. Two years later HOOD described *simplex* from specimens taken in Colorado, Nebraska and Illinois. In 1939 ANDRE described and figured the male from specimens taken in San Antonio, Texas.

DISTRIBUTION: Mexico, Colorado, Nebraska, Illinois, North Dakota, South Dakota, Iowa, Texas, Arizona, New Mexico, Washington, Montana, Alberta, Canada.

HOSTS: *Bontelona curtispindula*, Arctic sinpine, *Anaphalis subalpina*, *Lathyrus*, and other grasses.

Ch. falsus is close to *secalis* but separated from it by the moderately produced head in front of eyes.

Chirothrips frontalis Williams

(Fig. 9)

1914. *Ch. frontalis* Williams, *Entomologist*, XLVII, pp. 51-53.

1941. *Ch. frontalis* Williams, Andre, *Annals Ent. Soc. Amer.*, XXXIV, p. 455.

FEMALE (macropterous). — Color uniform dark brown, fore tibia and all tarsi a little paler, the third segment of the antenna distinctly lighter.

Head longer than wide, produced beyond the eyes into a long prominence more than half as long as the remainder of the head; eyes dark and relatively far back; ocelli distinct and subequal. Antennae 1.5 as long as head; unforked sense cone on the third and fourth segments.

Thorax: the whole surface of the pronotum finely striated and with a number of minute setae scattered over its surface; two long spines at each posterior angle of prothorax. Fore wings pale brown, hind wings clear.

Abdomen normal.

Measurements (in mm.): Length 1.60; head, length 0.1280, width 0.1185; distance from base of antenna to anterior margin of eyes 0.0200; length of cheek 0.0250; prothorax, length 0.2176, greatest width 0.2565; abdomen, greatest width 0.3240.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.0192	0.0352	0.0288	0.0350	0.0285	0.0440	0.0096	0.0120
width	0.0384	0.0320	0.0260	0.0256	0.0224	0.0192	0.0064	0.0050

Total length of antenna 0.224.

MALE unknown.

Redescribed from a female taken in Cheyenne, Wyoming, June 21, 1949, sweeping, S.F. BAILEY, 1 female.

Originally described from eleven macropterous females taken near Buenos Ayres, Argentina, in January, 1913, by W.O. BACKHOUSE. MOULTON later recorded this species from South Africa. Type is in the Hope Department, Oxford University Museum.

The writer noticed a slight difference between the specimen studied and the original description, namely in the position of the posterior pair of setae on vertex; in this specimen it is slightly in front of the anterior margin of the median ocellus. These differences make it seem plausible that there exists a subspecies. A study of types of the species involved would be necessary to arrive at the correct decision.

Chirothrips manicatus Haliday

(Figs. 3-4)

- 1836. *Thrips (Chirothrips) manicata* Haliday, *Entomo. Mag.*, III, p. 444.
- 1838. *Thrips manicata* Burmeister, *Handb. d. Entomologie*, II, p. 413.
Thrips longipennis Burmeister, *Ibid*, II, p. 413.
- 1843. *Chirothrips manicata* Amyot-Serville, *Ins. Hémiptères*, p. 642.
- 1843. *Chirothrips longipennis* Amyot-Serville, *Ibid*, p. 642.
- 1852. *Thrips (Chirothrips) manicata* Haliday, Walker, *Homopt. Ins. Brit. Mus.*, p. 1106, pl. VI, fig. 12.
- 1883. *Chirothrips antennatus* Osborn, *Canad. Ent.*, XV, p. 154.
- 1894. *Chirothrips manicata* Jablonowski, *Termes. Fuzetek*, XVII, p. 47.
- 1903. *Chirothrips manicatus* Hinds, *Proc. Nat. Mus.*, XXXIV, p. 134.

FEMALE (macropterous). — Length about 1.08 mm. Color dark brown or blackish brown; all tarsi nearly are quite yellow; wings brown, paler at base; antennae with segment I concolorous with head, segment II paler at tip, III brownish-yellow, IV-VIII uniform grayish-brown.

Head about as long as wide and nearly 0.6 as long as pronotum, distinctly produced in front of eyes, the sides of this process straight; vertex with three pairs of setae, the posterior pair is a little in advance of anterior margin of median ocellus; ocelli normal, the median are smaller. Antennal segment I oval in shape; II inverted foot-shaped, the apex with a minute terminal seta, III pyriform with rather long, slender pedicel. Mouth cone typical, broadly rounded, its length beyond posterior dorsal margin of head about 0.102 mm.

Prothorax is 1.66 times as long as head, pronotum with the lines of sculpture dark and moderately strong; surface covered with scattered setae, inner spines at posterior angles of pronotum about 0.039 mm, outer spines 0.035 mm. Mesothorax a little broader than pronotum. Metathorax narrower. Fore wings covered with microscopic hairs, with two veins disappearing at the tip, anterior vein with four or five setae, the posterior vein with six or seven.

Abdomen 1.25 times as wide as prothorax, with distinct dark lines on dorsal surface; posterior margins of sterna II-V dentate, these lobulate flanges become

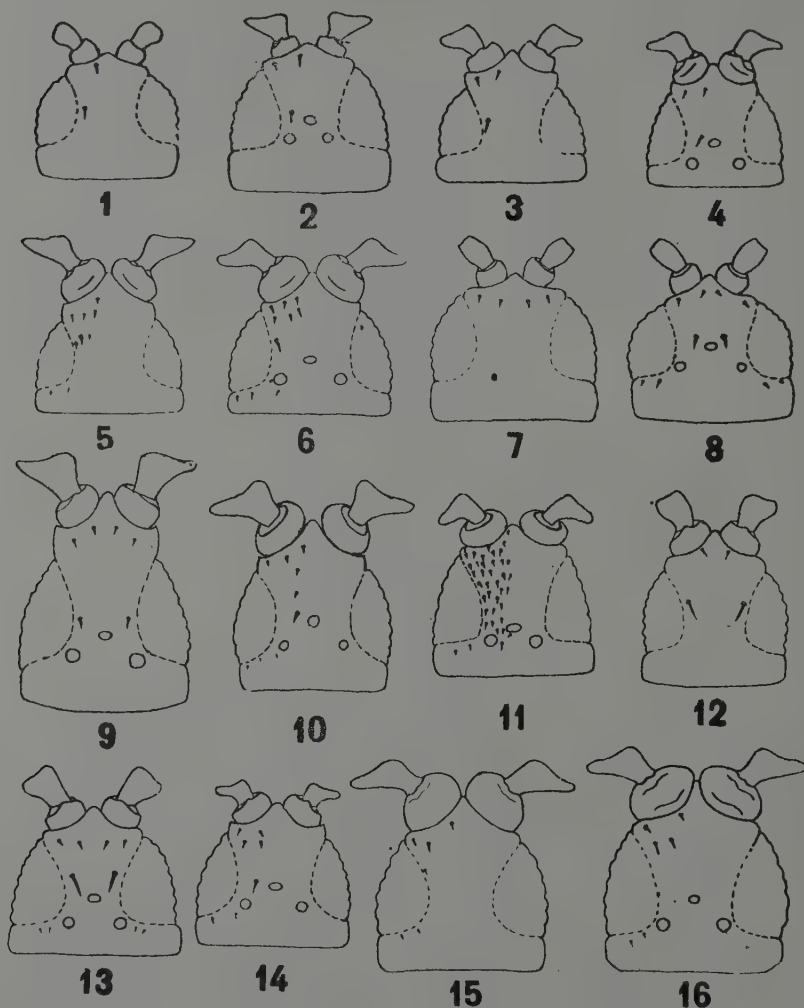


FIG. 1: Head of *Ch. aculeatus*, male. — FIG. 2: Head of *Ch. aculeatus*, female. — FIG. 3: Head of *Ch. manicatus*, male. — FIG. 4: Head of *Ch. manicatus*, female. — FIG. 5: Head of *Ch. spiniceps*, male. — FIG. 6: Head of *Ch. spiniceps*, female. — FIG. 7: Head of *Ch. secalis*, male. — FIG. 8: Head of *Ch. secalis*, female. — FIG. 9: Head of *Ch. frontalis*, female. — FIG. 10: Head of *Ch. crenulatus*, female. — FIG. 11: Head of *Ch. texanus*, female. — FIG. 12: Head of *Ch. falsus*, male. — FIG. 13: Head of *Ch. falsus*, female. — FIG. 14: Head of *Ch. productus*, female. — FIG. 15: Head of *Ch. mexicanus*, male. — FIG. 16: Head of *Ch. mexicanus*, female.

All illustrations were made by the writer without the aid of a camera lucida. They are roughly 225 times the natural size.

less conspicuous and more confined to lateral portions on sterna IV and V. Dorsal inner pair of spines of terga X strong and 0.099 mm long, those of terga IX about 0.064 mm.

Measurements (in mm.): Length about 1.29; head, total length 0.096, width across eyes 0.1152; lateral length of head process 0.010; length of cheeks 0.0192; pronotum, median length 0.170, greatest width 0.270, width across anterior margin 0.140; mesothorax, greatest width 0.324; metathorax, greatest width 0.29; fore wing, length 0.320, width at middle 0.048; abdomen, greatest width 0.378.

Total length of antenna 0.170 mm.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.0160	0.0224	0.0260	0.0300	0.0160	0.0320	0.0090	0.0035
width	0.0360	—	0.0220	0.0256	0.0200	0.0185	0.0060	0.0040

MALE (brachypterous). — Length about 0.900. Color of abdomen, all tarsi and antennal segments II and III yellowish-brown, remainder brown.

Head about as wide as long; first antennal segment very little enlarged but still the largest width very close to third of the width of occiput. Two spines at each posterior end of prothorax.

Measurements (in mm.): Length 0.915; head, length 0.073, greatest width 0.089; lateral length of head process in front of eyes 0.009; length of cheeks 0.015; pronotum, length 0.140, greatest width 0.176.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.019	0.018	0.021	0.023	0.017	0.022	0.006	0.004
width	0.030	0.028	0.020	0.023	0.017	0.016	0.005	0.003

Total length of antenna 0.162 mm.

Redescribed from the following material:

California: Burney, May 20, meadow, S.F. BAILEY, 3 females. — New York: Oswegatchie, July 12, 1938, sweeping grass, BAILEY and HOOD, 8 females and 3 males. — Utah: Green River, August 10, 1947, C.F. KNOWLTON, 1 female. — Massachusetts: Middlebor, July 17, 1938, sweeping grass and clover, S.F. BAILEY, 1 male. — California: Mendocino Co., Philo, July 19, 1949, on grass, S.F. BAILEY, 3 females. — Canada: Ontario, St. Catharines, June 28, 1949, on peach, W.L. PUTMAN, 1 female.

DISTRIBUTION: England; Germany; Finland; Russia; Bohemia; United States: Iowa, Massachusetts, New York, Florida, Tennessee, Illinois, Kansas, Nebraska, Oregon, Canada, Virginia, Maryland, Pennsylvania.

HOSTS: Flower of various grasses and cereals, clover and wild carrot.

The writer has noticed a distinct variation within the population examined. Many forms have been described in Europe, but no literature concerning these varieties in the United States has been found. In ANDRE'S Key to the American species of *Chirothrips* (1939) this species runs to *orizaba* Hood.

This species is closely related to *Ch. aculeatus*, but it is easily separated from it by the presence of a minute bristle at the extreme end of the apex of the second antennal segment, and by the straight lateral margin of the praecocular process.

Chirothrips mexicanus Crawford

(Figs. 15-16)

1909. *Ch. mexicana* Crawford, *Pomona College Jour. Ent.*, I, p. 114.
 1920. *Ch. floridensis* Watson, *Fla. Ent.*, IV (2), pp. 21-22.
 1923. *Ch. floridensis* var. *catchingsi* Watson, *Fla. Agr. Expt. Sta. Bull.*, 168, p. 76.
 1928. *Ch. maxicanus* Moulton, *Proc. Hawaii. Ent. Soc.*, VII, pp. 106-107.
 1939. *Ch. mexicanus* Moulton, *Proc. Ent. Soc. Wash.*, XLI (6), fig.

FEMALE (macropterous). — Length 1.2 mm. Color uniform brown; tarsi and third antennal segment lighter.

Head somewhat wider than long; cheek arched, about two-fifths as long as eyes; front prolonged triangularly between insertion of antennae; with eight small setae in front of the ocelli and two very small post ocular setae on each side; ocelli large, pale, anterior ocellus situated at median line of eyes. Antenna twice as long as head, stout with only a few bristles; basal segment concolorous with body, with dark transverse line; segment II light yellow, prolonged outwardly into a long acute apophysis with a small sense cone at tip; III and IV with a prominent sense cone on outer anterior angle; VI elongate with two small sense cones.

Prothorax sides with a deep indentation above coxa and a short, black chitinized line curving in from it, with one prominent spine on each posterior angle; fore wings light brown, surface covered with microscopic hairs, with one median longitudinal vein, which disappears before the middle of the wing.

Abdomen: segments one to five distinctly beaded on posterior dorsal margin, the fifth less so than others.

Measurements (in mm.): Total length 1.215; head, length 0.109, width 0.106; prothorax, length 0.189, width 0.229; abdomen, width 0.310.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.0224	0.0256	0.0256	0.0256	0.0288	0.0320	0.0160	0.0128
width	0.0416	—	0.0256	0.0288	0.0224	0.0160	0.0096	0.0064

Total length of antenna 0.181.

MALE (brachypterous). — Length 0.94 mm. Color of thorax, head and fore legs yellowish-brown, abdomen brown, darker at the posterior end.

Head much like female but ocelli wanting; vertex with three pairs of setae, the posterior pair situated far forward opposite anterior third of eyes; first antennal segments greatly enlarged; head moderately produced in front of eyes, lateral margin of process arched.

Measurements (in mm.): Length 0.94; head, length 0.096, greatest width 0.085; lateral length of head process in front of eyes 0.009; length of cheeks 0.020; pronotum, length 0.170, greatest width 0.185.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.025	—	0.023	0.026	0.022	0.022	0.010	0.007
width	0.038	—	0.024	0.030	0.025	0.017	0.008	0.006

Total length of antenna 0.165.

Redescribed from the following materials:

Kentucky: Hazard, July 18, 1948, ex wild grape, W.W. WATKINS, 1 male.—
California: Pixley, June 21, 1949, on grass, 3 females; Burney, May 20, 1950, meadow, 2 females.

Ch. mexicanus was originally described from one female collected on tobacco flowers at Guadalajara, Mexico. Later WATSON described the synonym *floridensis* from specimens taken in Florida, August 24 by sweeping Bermuda grass. MOULTON (1928) described the male from specimens taken in Hawaii.

DISTRIBUTION: Mexico, Philippines, West Indies, South America, Hawaii, Manila. In the United States it is recorded from Arizona, Florida, and Louisiana.

HOSTS: Flowers of tobacco (*Nicotiana tabacum*), Bermuda grass and date seedling leaves.

***Chirothrips productus* Hood**

(Fig. 14)

1927. *Ch. productus* Hood, Jour. N.Y. Ent. Soc., XXXV, p. 126.

FEMALE (macropterous). — Length about 1.15 mm. Color very dark brown, tarsi, third antennal segments and apex of the second paler; ocelli pigment redish; eyes black; fore wings brown, hind wing almost clear.

Head, a little longer than wide, usually four pairs of setae on vertex, the posterior pair somewhat stronger and situated slightly in front of median ocellus; cheeks straight and parallel; head distinctly produced in front of eyes, the distance from anterior margin of eyes to base of antenna about one-half the length of cheeks. Median ocellus is slightly smaller than the other two. Antenna about 1.8 times as long as head; segment II not shoe-shaped, with outer angle distinctly produced, but without sense cone on extreme apex.

Prothorax about 1.8 times as long as head and about 1.2 times as wide as long; pronotum with scattered minute setae and prominent sculptures; the two pairs of spines at posterior angles moderately long (0.032 and 0.025 mm). Fore wings covered with microscopic hair and have two distinct veins.

Abdomen a little broader than pterothorax; segment X about 1.4 times as long as basal width, the lateral spines of this segment about 0.090 mm.

Measurement (in mm.): Length 1.15; head, length 0.115, greatest width 0.105; length of cheeks 0.025; lateral length of head process in front of eyes 0.012;

prothorax, length 0.180, greatest width 0.243; mesothorax, greatest width 0.270; abdomen, greatest width 0.283.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.019	0.025	0.022	0.032	0.025	0.033	0.096	0.060
width	0.032	—	0.022	0.024	0.019	0.017	0.060	0.035

Total length of antenna 0.160.

No male is available for study.

Redescribed from one female collected in Idaho, Butte County, Bear Creek, July 26, 1947, sweeping, R.M. BOHRAT.

HOOD originally described this species from five females collected in North Dakota, Colorado and Utah. At the end of the original description he notes that this species is a member of the *manicatus* group.

This species is separated from *manicatus* by the lack of the small seta at the extreme apex of the second antennal segment.

Chirothrips secalis Moulton

(Figs. 7-8)

1935. *Ch. secalis* Moulton, *Pan-Pacif. Ent.*, XI, pp. 173-174.

FEMALE (macropterous). — Length about 1.4 mm. Color very dark blackish-brown except all tarsi and third antennal segment which are brown.

Head slightly wider than long; vertex very smooth with three pairs of setae, the posterior pair opposite the anterior margin of median ocellus; occiput with few dark transverse lines. Eyes about 0.5 times as long as head; ocelli sub equal, posterior pair situated opposite the posterior margin of eyes. First antennal segment not enlarged; segment II simple, not produced laterally.

Prothorax 1.6 as long as head and 1.2 as wide as long, with a distinct sculpture on the surface and scattered setae, each posterior angle with two prominent long spines (0.064 mm.). Pterothorax wider than prothorax; wings brown, covered with microscopic hairs and with two distinct veins.

Abdomen, almost as wide as pronotum, posterior margin of sternites I-VIII very heavily dentate; terga with distinct transverse lines; segment X two times as long as wide at base, with strong setae about 0.130 mm.

Measurements (in mm.): Length 1.42; head, length 0.128, greatest width 0.137; length of cheek 0.032; length of median head process in front of eyes 0.016; pronotum, length 0.208, greatest width 0.283; mesothorax, greatest width 0.391; metathorax greatest width 0.351; abdomen greatest width 0.357.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.019	0.035	0.032	0.028	0.032	0.038	0.010	0.006
width	0.029	0.029	0.024	0.022	0.021	0.020	0.008	0.005

Total length of antenna 0.240.

MALE (brachypterous). — Length about 1 mm. Color blackish-brown except tarsi and third antennal segments which are brownish-yellow.

Head much like female but ocelli wanting; first antennal segment not enlarged; segment II not produced laterally, barrel shaped.

Measurements (in mm.): Length 1.08; head, length 0.095, greatest width 0.112; length of cheek 0.031; pronotum, length 0.163, greatest width 0.169.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.019	0.029	0.029	0.032	0.024	0.035	0.007	0.005
width	0.025	0.020	0.021	0.021	0.200	0.017	0.005	0.003

Total length of antenna 0.168.

Redescribed from a female collected in Bass Lake, California, June 7, 1938, on Marsh grass, by S.F. BAILEY and a male collected in Grand Teton National Park, Wyoming, July 21, 1947, R.M. BOHART.

Originally described from eleven females taken in Willow Ranch, Modoc Co., California, July 9, 1929.

Chirothrips spiniceps Hood

(Figs. 5-6)

1915. *Ch. spiniceps* Hood, Ins. Insc. Mens., III, pp. 12-15, pl. I, fig. 8.

1939. *Ch. spiniceps* Andre, Proc. Ent. Soc. Wash., XLI, pp. 198.

FEMALE (macropterous). — Length about 1 mm. Usually bicolored (brown and yellow); head and thorax yellowish-brown, the head and sides of thorax darker; abdomen yellow shaded with brown; antenna, first segment yellowish-brown, second and third yellow, the others brown; first tibia and all tarsi yellow.

Head very slightly wider than long; cheeks slightly arched, usually about one-sixth as long as head; distance from anterior margin of eyes to base of antenna equal to two-thirds the length of cheeks; seven pairs of short, stout setae near base of antennae in addition to a slightly longer pair opposite anterior fifth of eyes; three other pairs of minute setae at posterior margin of eyes; ocelli equal in size. Antenna 1.7 times as long as head; segment I egg-shaped, segment II inverted shoe-shaped, segment III pyriform with rather long slender pedicel.

Prothorax about 1.6 times as long as head and nearly 1.5 times as wide as long; hind angles with only one moderately long spine. Pterothorax about 1.25 times as wide as prothorax and slightly wider than abdomen; wing shaded with gray, especially at base and apex.

Abdomen smooth, twice as long as wide. Segment X slightly longer than basal width.

Measurements (in mm.): Length 1.17; head, length 0.112, greatest width 0.121; lateral length of head process 0.011; length of cheek 0.019; pronotum

length 0.178, greatest width 0.28; width of mesothorax 0.335; greatest width of abdomen 0.335.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.022	—	0.032	0.032	0.023	0.035	0.010	0.006
width	0.045	—	0.022	0.024	0.022	0.019	0.005	0.003

Total length of antenna 0.192.

Male (brachypterous). — General color lighter than female, yellowish with terminal segments of antennae and abdomen shaded with brown.

Head strongly produced in front of eyes; ocelli wanting; antennae much as in female; lateral setae on segment IX of abdomen 0.076 mm. long.

Measurements (in mm.): Length about 1; head, length 0.105, greatest width 0.106; lateral length of praecocular process 0.016; length of cheek 0.018; pronotum, length 0.170, greatest width 0.243; mesothorax greatest width 0.270; abdomen greatest width 0.280.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.030	—	0.030	0.029	0.0019	0.031	0.009	0.008
width	0.038	—	0.025	0.027	0.0021	0.017	0.007	0.004

Total length of antenna 0.186.

Redescribed from the following materials:

California: Chowchilla, November 15, 1939, sweeping grass on ditch bank, S.F. BAILEY, 2 females; Poso Cr., Kern Co., April 22, 1951, on grass lupine, by S.F. BAILEY, one male.

Ch. spiniceps was originally described from a series of females collected in Arizona, Texas, and Louisiana, the type locality being the region of Glendale and Phoenix, Arizona. In 1939 ANDRE described the male from specimens collected at Phoenix and Tempe, Arizona, on various grasses.

DISTRIBUTION: Arizona, California, Florida, Louisiana, New Orleans, North Carolina, Texas, Virginia.

HOSTS: Various grasses.

Chirothrips texanus Andre

(Fig. 11)

1939. *Ch. texanus* Andre, *Proc. Ent. Soc. Wash.*, XLI (6), pp. 200-202.

FEMALE (macropterous). — Length 1.52 mm. Usually dark brown; abdomen, hind tibiae, and all tarsi distinctly paler.

Head with its total median length equal to or slightly less than its greatest width, distinctly produced in front of eyes, sides of praecocular process strongly converging posteriorly; vertex normally with about 36 to 44 pairs of short, stout

setae, posterior pair situated between posterior ocelli within the ocellar triangle; occiput with two additional pairs of minute setae just behind the eyes; cheeks nearly straight and parallel, about a sixth as long as head, almost continuous with margin of eyes. Ocelli large, posterior pair opposite posterior margin of eyes. Antenna about 1.4 times as long as head; segment I greatly enlarged, its greatest width being almost one-half that of basal width of head; segment II inverted foot-shaped with small seta at tip of process; segment III pyriform with prominent stout sense cone.

Prothorax about twice as long as head and about 1.4 times as broad as long; pronotum without sculpture, closely set with short setae; each posterior angle with two prominent spines about 0.045 mm. long. Pterothorax a little wider than prothorax.

Abdomen as broad as prothorax, segment X not elongate or acute, with spines about 0.120 mm.

Measurements (in mm.): Length 1.52; head, length 0.121, greatest width 0.125, lateral length of head process 0.009; length of cheek 0.025; pronotum, length 0.230, greatest width 0.270; mesonotum, greatest width 0.330; abdomen, greatest width 0.330.

Antennal segments:	I	II	III	IV	V	VI	VII	VIII
length	0.028	0.031	0.0330	0.0340	0.029	0.036	0.0128	0.0064
width	0.054	—	0.0220	0.0224	0.019	0.017	0.0050	0.0030

Total length of antenna 0.208.

MALE not available for study.

This species is easily separated from the others by the large number of setae on the vertex of the head.

Redescribed from a paratype: Texas, Wichita Falls, August 26, 1936, FLOYD ANDRE.

Holotype: U.S. National Museum No. 53265.

TYPE LOCALITY: Denson Texas.

HOSTS: Clover and various grasses.

This species is easily separated from all the others by the large number of setae on the vertex of head (36-44 pairs).

A LIST OF THE *CHIROTHRIPS* SPECIES OF THE WORLD

Aculeatus Bagnall, 1927, recorded in California; *aethiops* Bagnall, 1932; *africanus* Priesner, 1932; *ambulans* Bagnall, 1932; *ammophilae* Bagnall, 1927; *angusticornis* Bagnall, 1932; *atricorpus* Girault, 1934; *auriventris* Hood, 1939, recorded in America; *bagnali* Hood, 1938; *bradlagi* Hood, 1941, recorded in America;

crassus Hinds, 1903, recorded in America!; *crenulatus* Hood, 1927, recorded in America; *cuneiceps* Hood, 1940, recorded in America; *cypristes* Hood, 1938; *dorsalis* Hood, 1939, recorded in America; *dudae* Uzel; *falsus* Priesner, 1925, recorded in California; *frontalis* Williams, 1914, recorded in California; *fulvus* Moulton, 1936; *hamatus* Trybom, 1895; *hoodi* Jacot, Guill., 1941; *insolitus*, Hood, 1915, recorded in America; *insularis* Hood, 1938; *laingi* Bagnall, 1932; *lenape* Hood, 1938, recorded in America; *manicatus* Haliday, 1836, many forms recorded in California; *meridionalis* Bagnall, 1927; *mexicans* Crawford, 1909, recorded in California; *molestus* Priesner, 1926; *orizaba* Hood, 1938, recorded in America; *pallidicornis* Priesner, 1925; *patruelis* Hood, 1940, recorded in America; *pedestris* Karny, 1949; *praeocularis* Andre, 1941; *priesneri* Hood, 1949; *productus* Hood, 1927, recorded in America; *pubescens* Hood, 1949; *ruptipennis* Priesner, 1938; *ruthae* Hood, 1949; *secalis* Moulton, 1935, recorded in California; *sensitivus* Andre, 1939, recorded in America; *sericatus* Hood, 1949; *similis* Bagnall var. *productus*, 1932 (this species is apparently a homonym); *spiniceps* Hood, 1915, recorded in California; *spinosus* Moulton, 1946; *spinulosus* Andre, 1941; *takahashii* Moulton, 1928; *talpaides* Hood, 1939, recorded in America; *texanus* Andre, 1939; *vestis* Hood, 1915, recorded in America; *watanabei* Ishida, 1931; *xanthius* Hood, 1933.

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SEXUAL DIMORPHISM IN THE SECOND INSTAR OF *CHRYSOMPHALUS FICUS* ASHMEAD

[Homoptera: Coccoidea-Diaspididae]

(with 2 Text-Figures)

by A. HABIB, PH.D.(1), Y.M. EZZAT, PH.D.(2) and Y.H. ATALLAH, M.SC.(3)

INTRODUCTION

The problem of sexual dimorphism in the second instar, is a point which has never been tackled before in *Chrysomphalus ficus* Ashmead. All previous attempts to distinguish between sexes in such a young instar were mainly concerned with the external appearance of the scale together with some morphological characters such as the shape and the colour of the body, the presence or absence of pigmented eye spots and the appearance of sexual appendages. Such characters are however of little value and cannot be used to distinguish between newly moulted instars of both sexes. The only real attempt to distinguish between sexes in such an instar was that carried out by BORATYNSKI (1953) who distinguished between them on basis of the structure of the pygidium and the body. His study was however carried out on other insects belonging to the *Diaspididae*.

Many attempts were also carried out by other authors on different insects. Among those the most important are BERLESE (1896), LOMBARDI (1938), BALACHOWSKY (1939), FERRIS (1942), STICKNEY (1943) and GEIER (1949).

MATERIAL

Most insects examined were collected from *Ficus retusa* and few from different kinds of citrus trees. The distinction between the two sexes shortly before the second moult is dealt with in another paper. This distinction was based on the study of

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the external characters of the scale. Preparations were made according to this distinction, and the microscopical characters were studied. These characters were used as a reference for other preparations of externally indistinguishable specimens. The fact that most males are on the upper surface of the leaf was also helpful.

The general feature of the body, measurements, segmentation and distribution of marginal setae were taken from specimens prepared in IMM's media and SWAM's media to avoid any probable effect of shrinkage in permanent preparations.

Characters as the number of ducts, the distribution of setae, sclerotization and the mouth parts etc., were examined in permanent preparations. These were obtained through the usual technique of making coccid mounts.

A minimum of 20 specimens of each sex were examined for each comparison.

RESULTS

Second instar, female

(Fig. 1)

LIVE MATERIAL: Immediately after the 1st moult the body is yellow, broadly oval, somewhat tapering towards the posterior end but after growing the body becomes rather rounded. In newly moulted individuals the body is about 329 (280-449) microns long and 281 (241-364) microns wide.

SEGMENTATION: Segments generally fused, more or less marked in pygidial part of abdomen and thorax by intersegmental marginal notches.

HEAD: Antennae with one curved lateral seta about 10 microns long, tubercle rugose, as long as broad, about 5 microns. Eyes apparently absent. Mouth parts normal, with a long rostral loop.

THORAX: Prothorax fused with head. Legs absent. Spiracular apodemes equidistant from the margins, enlarged and sometimes reticulate towards inner end.

ABDOMEN: Marked into eight segments by intersegmental marginal notches, lobes and segmental marginal setae. Prepygidium includes abdominal segments I, II, and III apparent and not fused. Pygidium well developed, large, broad, composed of the last five abdominal segments, sclerotized specially at the dorsal surface, segment IV partly sclerotized on dorsum, not sclerotized on venter. Openings of macroducts arranged in nonsclerotized dorsal farrows. Four pairs of lobes, L1 to L4, present on abdominal segments VIII to V, segment IV with no lobes but with a marginal obvious serrate protrusion. L1 to L3 sclerotized and well developed, L4 less sclerotized with an indented margin and variable dimensions; L1 about 10 microns long and 7 microns wide, distinctly notched in outer margin while the inner margin more or less straight; L2 about 9 microns long and 7 microns wide, notched from the inner and outer margins; L3 about 8 microns long and 6 microns wide, with outer margins slightly notched. Plates vary in size and shape, appear as fimbriate, fringed or serrate projections, 2 between every two subsequent lobes,

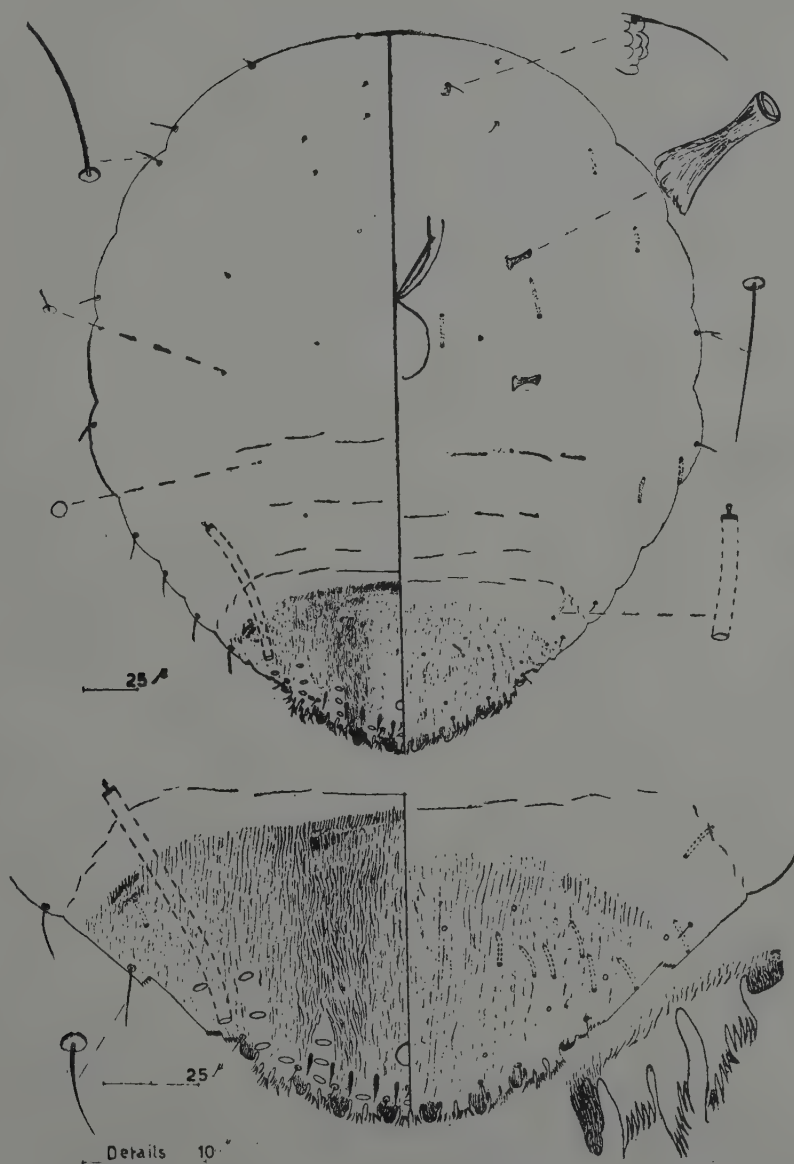


FIG. 1: *Chrysomphalus ficus* Ashmead: Second instar, female.

any of the plates between L2 and L3 and or between L3 and L4 may be deeply invaginated giving the appearance of three instead of two plates; between L4 and the marginal protrusion of segment IV, two non projecting plates are present. Paraphysis pyriform, about 13 microns long; five paraphysis present dorsally on each side of pygidial margin. Anal ring circular, about 8 microns in diameter, dorsal, spaced about two times its diameter from the posterior margin, more sclerotized anteriorly than posteriorly.

Dorsal body setae fine and short, about 2 microns; arranged on the cephalothoracic region in a submedian longitudinal row consisting of about two pairs and two single setae. Ventral setae similar in shape and length to dorsal setae though fewer in number, a couple of such setae could be spotted on the anterior part of the body. Marginal setae generally conspicuous, flagellate and longer, 15 (11-19) microns, those along the anterior margin of the head and on the pygidium are shorter, arranged along the margin in a double row represented by 2 setae on each side of every body segment except abdominal segments I, II and VIII, a single obvious seta is present mesally on dorsum near the posterior margin of the body. The term marginal setae is here preferred for these setae due to the fact that it may prove difficult to designate their exact morphological position.

Tubular ducts of two sizes only, macroducts and microducts, all one barred with a central bulla. Macroducts relatively very long, ranging from 60 to 100 microns long and 4 to 8 microns wide; 21 (19-23) ducts present on dorsum of pygidium only; one duct between the median lobes and the rest are arranged on each side in characteristic rows and groups about as follows: one duct between L1 and L2, 3 or 4 between L2 and L3, 4 between L3 and L4, 2 between L4 and the seta of abdominal segment IV. Sometimes, 2 macroducts of about 27 microns wide are situated mesally on the dorsal surface of the pygidium. Microducts smaller, 7-12 microns long and 1-2 microns wide; of varying number and position, generally on venter, apparently absent on dorsum; about 7 microducts on the ventral surface of pygidium, few others on marginal and submarginal areas of anterior abdominal segments and thorax.

Simple disc pores inconspicuous, may be distinguished on the median area of the body as follows: On dorsal surface, 4 on thorax and anterior part of abdomen; on ventral surface, 6 on pygidium and 2 on mesothorax.

Second instar, male

(Fig. 2)

LIVE MATERIAL: Just after the 1st moult the body is similar to that of the female, but later it becomes elongate oval with two dark pigmented spots on the head. In newly moulted individuals the body is about 322 (280-364) microns long and 264 (221-299) microns wide, i.e., in general smaller than the female.

SEGMENTATION: Segments more distinct than those of the female.

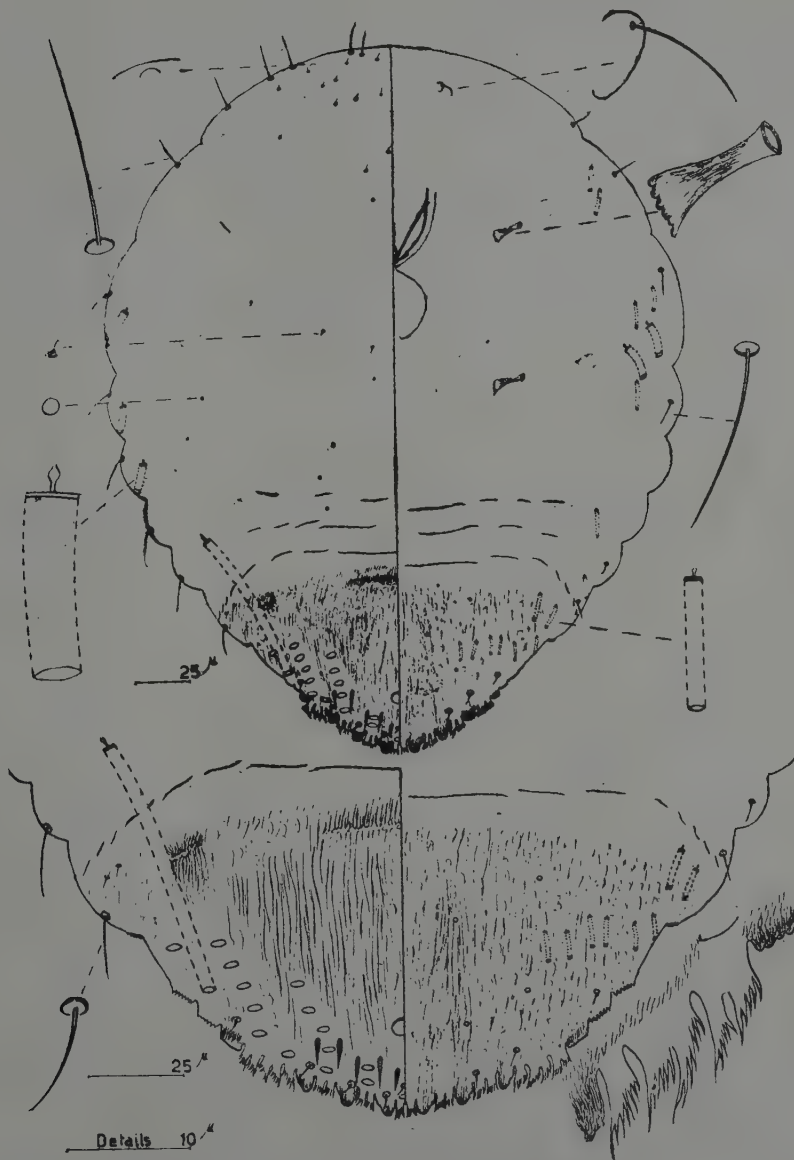


FIG. 2: *Chrysomphalus ficus* Ashmead: Second instar, male.

HEAD: Antennae conical, widest diameter about 5 microns, with one curved seta at the apex, about 11 microns long. Eyes always present although they may escape observation specially in newly moulted individuals, appear after moulting as simple convex dome-like structures but soon they develop and become conspicuous and darkly pigmented. Mouth parts similar to those of the female.

THORAX: Legs and spiracular apodemes as in the 2nd instar female.

ABDOMEN: Generally similar to that of the 2nd instar female. However the protrusion of segment IV is less obvious and the lobes are consistently smaller but the difference is not significant; L1 about 9 microns long and 7 microns wide, L2 about 8 microns long and 7 microns wide; L3 about 7 microns long and 6 microns wide; L4 with variable dimensions but usually about 6 microns long and 5 microns wide. Plates similar to those of the female except that the two plates between the median lobes are often trifid while tetrafid in the female and being with three plates between L3 and L4, of which the median and outer plates are invaginated giving the appearance of five plates. Paraphysis similar and anal opening similar to that in the case of the female.

Body setae similar to those of the 2nd instar female except that the dorsal body setae are arranged on the cephalo-thoracic region in five rows extending from mid line to margin consisting of about 4, 3, 4, 2 and 2 setae respectively; 2 setae are also present on abdominal segment IV. Ventral setae absent. Marginal setae generally longer than corresponding setae in female, 19 (15-22) microns, 6 setae are present on each side of the marginal area of the head, while these are 3 only in female.

Tubular ducts of three sizes: macroducts, short macroducts and microducts; all one barred with a central bulla. Macroducts similar in shape and size to those of the 2nd instar female but differ in number, 29 to 31 macroducts on dorsum of pygidium, one duct between the median pair lobes, and the rest arranged on each side in characteristic rows about as follows: 2 between L1 and L2, 5 between L2 and L3, 6 or 7 between L3 and L4 two of which are marginal, 2 between L4 and the seta of abdominal segment IV. Short macroducts constitute a series of conspicuous short but comparatively wide macroducts, 10-15 microns long and 3-5 microns wide, about 10 ducts are present, 5 on each side of the body in the lateral regions of abdominal segment I, metathorax, and mesothorax, 2 of which are definitely ventral while the rest are apparently marginal.

Microducts similar in shape and size to those of the 2nd instar female but more numerous, present on marginal and submarginal areas of anterior abdominal segments and thorax.

Simple disc pores inconspicuous, may be distinguished on the median area of the body as follows: On dorsal surface, 8 on thorax and anterior part of abdomen; on ventral surface, about 4 on pygidium and one on mesothorax between the two spiracular apodemes.

SUMMARY

Diagnostic differences between the 2nd instar of the two sexes in *Chrysomphalus ficus* may be summed up as follows:

Darkly pigmented eye spots conspicuous in the male only. Plates between L3 and L4 normally 3 in male and 2 in female. Dorsal setae on anterior area of head more numerous in male. Marginal setae between antennae, generally longer and more numerous in male than in female, always more than 4 in male while 2 only in female. Dorsal macroducts of pygidium; between L1 and L2, 2 in male and 1 in female; between L2 and L3, 5 in male and 3 in female; between L3 and L4, 6 in male and 4 in female. Short macroducts present in male, 5 on each side of the body in the lateral regions of abdominal segment I, metathorax and mesothorax, absent in female.

ACKNOWLEDGMENT

The writers wish to express their thanks to Professor A.A.G. HASSAN, head of the Department of Plant Protection, for offering all facilities throughout the work.

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BEHAVIOUR OF LARVAE AND ADULTS OF THE COTTON LEAF WORM, *PRODENIA LITURA* (FABR.)

[*Lepidoptera: Noctuidae*]

(with 3 Text-Figures)

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INTRODUCTION

The cotton leaf worm, *Prodenia litura* (Fabricius) has long been established in Egypt as a major pest on cotton and other crops. However, characteristics of its behaviour have been partially explained in the literature. This paper presents a study on the behaviour of the larval and adult stages of this moth. Observations reported herein were conducted in the laboratory of the Plant Protection Department and fields of the Ministry of Agriculture at Dokki, during the summer, 1958.

MATERIALS AND METHODS

Larvae of the cotton leaf worm were placed under close observations immediately after hatching. For this purpose, a number of cotton plants in pots with egg-masses freshly laid on leaves were transferred from the field to the laboratory. Therefore, the pattern of behaviour of the first instar larvae was recorded.

Studies on the activities of larvae in the fourth instar were conducted in the field during June. Fifty larvae were used in the experiment. One larva was caged with a young cotton plant in a glass jar (16 cm. in height, 8 cm. in diameter), opened

at both ends. Each jar was closed at the top with cheese cloth and secured with a rubber band. All cages were kept out-doors in a shaded place. Observations were made at hourly intervals throughout the day on the activities of the larvae during their vertical movement on plants or horizontal movement on soil surface or during feeding. Temperature and relative humidity of the atmosphere in the vicinity of the cages were recorded at the time of observation by means of a thermometer and a rotary psychrometer. Each type of activity, recorded for a single cage, was designated by a mark and totalled for every hour of observation. Readings of three-days observations were then averaged and plotted on a curve to indicate time of activity of larvae in relation to air temperature and its relative humidity.

During July diurnal activities of moths were investigated also in the field. Fourty pairs of recently emerged moths were used for this purpose. Each pair was caged with a small cotton plant in a glass jar opened at both ends and set on a flower pot. A cotton flower, with its stem immersed in a vial full of water, was introduced in each cage to provide food for moths. All cages were put in a shaded place out-doors. Hourly records were kept for each type of activity whether flying, feeding, mating or ovipositing as well as for temperature and relative humidity of the atmosphere in the vicinity of the cages. All records obtained were treated in a manner similar to those reported for activities of fourth instar larvae.

Information was also obtained on the time of emergence of moths during the period between September 28th and October 14th. Larvae about to pupate were singly put in 250 cc. beakers, two-thirds full with light clay soil of 30 per cent moisture content. After pupation, 50 beakers were kept in the laboratory while an equal number of breakers was put out-doors. The number of emerging moths was then recorded every hour throughout the day.

RESULTS AND DISCUSSION

I. Behaviour of larvae

A. BEHAVIOUR OF NEWLY HATCHED LARVAE. — Adults of Lepidoptera lay their eggs in clusters or loose batches or scattered on plant leaf. Opportunity for formation and maintenance of aggregations of young larvae in the field is greater for the first case while in the third case the isolated individuals may be more typical for the normal tendency. Aggregates behaviour in lepidopterous larvae, was observed by LONG (1955) in both *Pieris brassicae* L. and in *Plusia gamma* L. and by BISHARA (1934), WILLCOCKS and BAHGAT (1937) and WIESMANN (1952) in *Prodenia litura* (Fab.).

Larvae of the cotton leaf worm exhibit a unique pattern of behaviour from time of hatching until time of pupation. Shortly after hatching, larvae remained in aggregates at the site of egg-mass before they wandered about into different directions. Formation of small groups or aggregates, each of at least five larvae, took

place before the first aggregate proceeded away from the site of hatching. Other aggregates of the same size followed and the larvae began to disperse indiscriminately as they reached about one centimeter away from the initial site. Some larvae moved to the edge of the leaf but returned to their aggregates, while the rest crawled to the other side of the leaf. As a result the latter lost track of their aggregations. A few hours after dispersal they were seen hung to silken strands spun by the larvae. Sometimes, a number of larvae were seen hung on a single strand. However, slight disturbance of silken strands induced larvae to climb to the leaf surface. These strands helped the larvae to wander about on the leaves of the same plant and to adjacent ones. Also dispersal of the larvae from one plant to another took place by swinging movements of the larvae or by crawling. Young larvae crawled from the leaf to the stem and moved towards the top leaves where they aggregated again on the lower surfaces. Larvae fallen to the ground were seen crawling on the soil surface until they reached other plants.

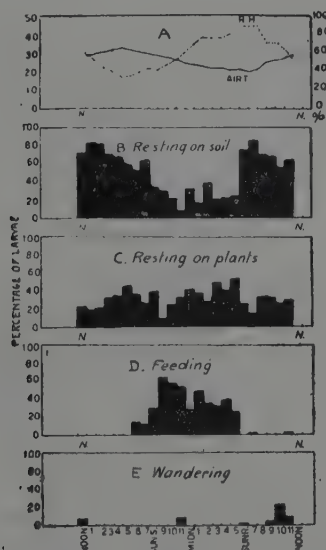


FIG. 1: Behaviour of advanced larvae (fourth instar) in the field, during June, 1958.

B. BEHAVIOUR OF ADVANCED LARVAE (fourth instar). — BISHARA (1934) and WILLCOCKS and BAGHAT (1937) stated that the larvae, when fairly big in size, spent the day almost motionless at the base of the plants but resumed their activity and ascended the plants for feeding late in the afternoon. Similar observations on the larvae in fourth, fifth and sixth instars were also reported by WIESMANN (1952).

Larvae of *Prodenia litura* (Fab.) are nocturnal in their activities. Experiments showed that during daytime, most larvae hid in soil in a quiescent state, but shortly before sunset they became active and climbed the plants. At night, about 74% of the larvae were seen on plants either feeding or moving. The largest number of larvae observed feeding on plants at one time (9.30 p.m.) was 37. When dawn set in (about 5 a.m.), larvae began to descend the plants to the soil where they stayed for the rest of the day. However, about 7 a.m., 84 per cent of the larvae were found hidden in the soil (Fig. 1 B).

Cool weather with considerable humidity induced feeding and movement activities of the larvae. In the afternoon, about 4 p.m., when air temperature was 33°C. and relative humidity 34%, about 68% of the larvae under investigation were inactive. On the contrary, larvae became active as air temperature began to drop accompanied, in the meantime, with a steady rise in the relative humidity. Larval activity were about to cease in the early morning between 6 and 7 a.m., as the relative humidity of the air started to decrease and temperature began to rise (Fig. 1).

C. BEHAVIOUR OF FULL GROWN LARVAE. — Larvae, when full grown, moved to elevated areas of the field for pupation. This was observed upon examination of soil samples taken at random from berseem fields; as more pupae (5 pupae per square foot) were found in elevated areas than in plane ones (two pupae per square foot). Statistical analysis showed that the difference in number of pupae in elevated and plane areas was highly significant and was not due to chance distribution. A special study on the behaviour of the full grown larvae in relation to soil moisture is reported in a separate paper.

II. Behaviour of adults

A. TIME OF EMERGENCE. — According to WIESMANN (1952) moths of *Prodenia litura* emerge in day and night times. JARCZYK et al (1957) observed that female moths emerged between 11 a.m. and 3 a.m., with the majority emerging between 6 p.m. and 8 p.m., while male moths emerged between 1 p.m. and 1 a.m., with the majority emerging between 8 p.m. and 10 p.m.

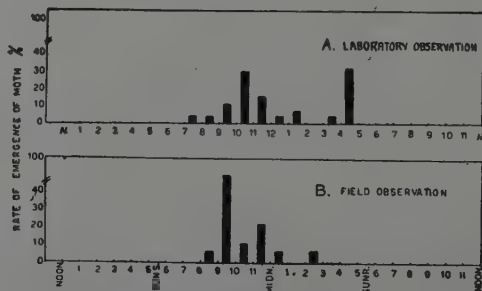


FIG. 2: Time of emergence of moths of the cotton leaf worm in both field and laboratory.

Emergence of moths occurred only at night. In the laboratory, moths emerged between sunset and sunrise, the majority emerging at dawn (Fig. 2, A). In the field, emergence took place between 8 p.m. and 3 a.m. with the majority emerging between 9 p.m. and 10 p.m. (Fig. 2, B). During the period of observation the mean temperature and relative humidity recorded in the laboratory were 26.2°C. and 63% while in the field, they reached 21.9°C. and 70%, respectively.

B. DIURNAL ACTIVITY. — BISHARA (1934) mentioned that moths of the cotton leaf worm are nocturnal in habits, hiding by day and actively flying for food, mating and oviposition during the evening and night. WILLCOCKS and BAHGAT (1937) added that the first two or three hours of darkness, especially during the first hour, was a very active period of the moths.

In the course of this investigation, about 80% of the moths were seen during daytime resting beneath cotton leaves or hiding in flowers (Fig. 3, B), although occasional flight took place during the day. This flight occurred between 1 and 2 p.m. when air temperature reached its maximum for the day and the relative humidity was at its lowest.

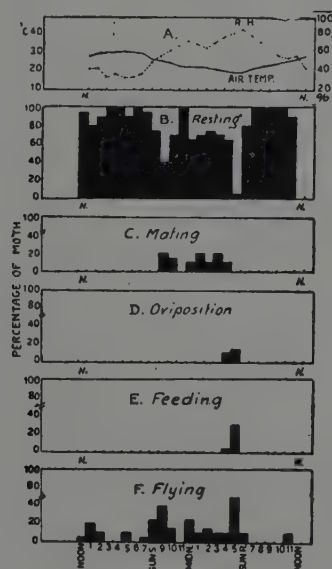


FIG. 3: Behaviour of moths of the cotton leaf worm in the field, during July, 1958.

Flight activities of moths are apparently governed by atmospheric conditions. Increase of relative humidity and decrease of temperature of the air seemed to induce flight. The first attempt of flight was noticed after sunset, coincident with a slight drop in temperature and a slow rise in the relative humidity. This flight

involved approximately 24% of the moths under observation (Fig. 3, A and F). The maximum flight activity took place at 5 a.m. when the relative humidity of the air reached its highest (85%) and the temperature was at its lowest (19°C.). This is contrary to WIESMANN's statement that the chief flight started only one hour after sunset.

Feeding of moths on nectaries of leaves and flowers were reported by WILLCOCKS and BAHGAT (1937) and also by WIESMANN (1952). In this experiment, feeding of moths on nectar of flowers took place just before sunrise between 4 and 5 a.m. At that time, moths visited the flowers and were seen with their proboscis extended and inserted in the nectaries. The highest record of moths observed feeding at one time included 30% of the total moths used (Fig. 3, E).

Copulation was reported by WILLCOCKS and BAHGAT (1937) to take place on the second night after emergence and to last from one to two hours. WIESMANN (1952) stated that copulation took place 1.5-2 hours after sunset and lasted about 3-4 hours. He also added in his detailed account of the copulation process that no mating took place when the temperature fell below 16.3°C.

Observations showed that mating occurred between 9 p.m. and 4 a.m. (Fig. 3, C). During this period, air temperature ranged between 24.5°C., and 19°C. while the relative humidity ranged from 62 to 85%. Copulation process lasted for a period ranging from twenty minutes to two hours and 40 minutes. Approximately 85% of the experimented moths mated on the first night after emergence, while only 5 per cent mated on the second night. Also 5% of the pairs, which mated on the first night after emergence, mated again on the third night. Mating occurred only once for females with the exception of few pairs which mated more than once during the three-days of observation.

Oviposition was reported by WILLCOCKS and BAHGAT (1937) to take place in summer on the night following emergence of moths but more usual on the third night. WIESMANN (1952) added that oviposition generally occurred throughout the same night of copulation and mostly at 1-1.5 hours after sunset in the laboratory. It was stated by BISHARA (1934) that commencement of egg-laying was mainly governed by temperature.

In the field, oviposition occurred during a period of 2 hours shortly before sunrise (Fig. 3, D). The maximum number of ovipositing females was observed at 5 a.m. when air temperature was 19°C. and the relative humidity was 85%. It was also reported that approximately 47% of the mated females laid eggs on the same night of mating, while the rest laid their eggs on the second or third night after copulation. The time involved in the laying of an egg-mass varied between 10 minutes to one hour and 45 minutes.

SUMMARY

Investigations were carried out in both field and laboratory on the behaviour of larvae and adults of the cotton leaf worm. It was found that:

(1) Newly hatched larvae aggregate for a short period at site of hatching, then disperse by crawling and by means of silken strands.

(2) Comparatively cool and humid weather at night induces movement and feeding activities of larvae.

(3) Emergence of moths occurs at night, the majority emerging between 9 and 10 p.m.

(4) Approximately 80% of moths rest during the day but at night the increase of atmospheric humidity and decrease of temperature induce flight activity.

(5) Feeding of moths on nectar of flowers takes place shortly before sunrise, between 4 a.m. and 5 a.m.

(6) The majority of pairs mate on the first night of emergence between 9 p.m. and 4 a.m. and the process of copulation lasts between 20 minutes to 2 hours and 40 minutes.

(7) Oviposition occurs during a period of 2 hours before sunrise and lasts between 10 minutes to 1 hour and 45 minutes. Approximately 50% of copulated females lay their eggs on the same night of mating.

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A CONTRIBUTION TO THE STUDY OF THE EGYPTIAN APHIDIDAE

(Hemiptera: Homoptera)

(with 3 Text-Figures)

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INTRODUCTION

THEOBALD (1913, 1915, 1918, 1920 and 1922), WILLCOCKS (1922) and HALL (1926) were the pioneers of taxonomic work on Aphididae in Egypt. Recently, ELKADY (1959) gave a survey for the Egyptian Aphididae and constructed a key to 80 species following the recent change of the nomenclature of the members of this family.

The present study is dealing with 3 species as a further contribution to the taxonomic studies on Aphididae carried by the writer in Egypt. These 3 species are the apterous viviparous female of *Macrosiphoniella parthinii* n. sp., the alate viviparous females of *Neotoxoptera violae* Pergande and *Paczoskia turanica* (Nevsky) as new records in Egypt. The alate viviparous female of *M. parthinii* is described by ELKADY (1959) as a new species and yet the writer could collect the apterous forms from the same host plant, *Chrysanthemum parthinifolium*. A morphological description for the apterous form of the new species and redescription for the alate forms of the two other species are clearly illustrated with a biometric data for their different parts.

Specimens sent to the British Museum (Natural History) were kindly identified by Dr. V.F. EASTOP.

Macrosiphoniella parthinii, n. sp.

APTEROUS VIVIPAROUS FEMALE (Fig. 1): General colour of the body green. Head greenish white dorsally and yellowish green ventrally. Antennae with yellow.

wish green scape and pedicel; flagellum light black and semi-translucent. Eyes red. Tip of proboscis black while the rest is green to yellow. Thorax green with white waxy patches. Legs with light green coxae while the rest is light black and heavy black at the tibio-femoral junction, at the distal part of the tibia and at the tarsus.

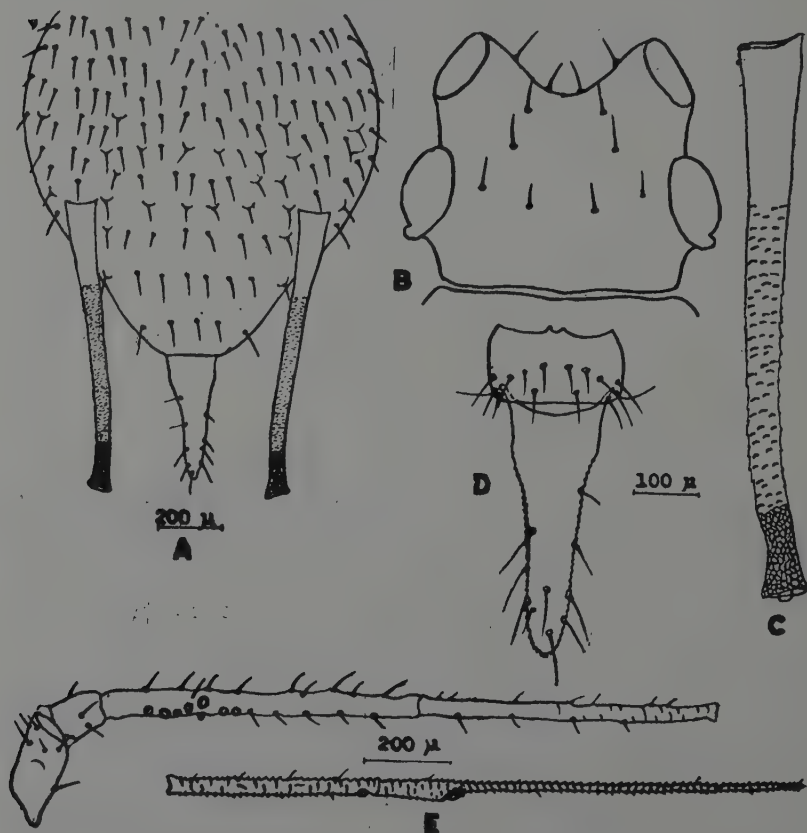


FIG. 1: *Macrosiphoniella parthinii* n. sp. (aptera): A, abdomen (dorsal view); B, head (dorsal view); C, siphunculus; D, anal plate and cauda (ventral view); E, antenna.

Abdomen light green and pear-shaped with a longitudinal mid-dorsal green line. Two lateral green lines are also present. Six horizontal rows of small white spots are dorsally arranged on the six abdominal segments. A number of white spots on each of the rows is as follows: 8 on first; 10 on 2nd, 3rd and 4th; 6 on 5th (between bases of siphunculi); and 4 on the 6th. Siphunculi long, cylindrical, diverging

and terminally dilated. They lie horizontally in the same plane of the body when at rest. Their colour is black with a greenish basal part (1/3). Cauda light green. Anal plate green.

Microscopical characters: Frontal tubercles well developed and diverging. Triommatidion present. Antennal hairs short (30 μ); secondary rhinaria on 3rd antennal segment 9 ranging 3-12, confined to the 1/2 basal part of the segment; antennal formula 6-3-4-5; unguis about 4.2 times as long as the basal part. Apical rostral segment acuminate with 6 secondary hairs. First hind tarsal segment with 3 hairs. Abdomen clothed with numerous hairs (50 μ). Abdominal sclerites absent. Siphunculi with 1/3 basal part yellowish and the rest sclerotised; polygonal reticulation at the apex about 1/5-1/6 the whole length. Cauda elongate bearing 10 hairs.

Measurements in mm.:

No.	Length of body	Ant.	Siph.	Cauda	Apical rostr. seg.	2nd hind tarsus	Antennal segments					No. Rhin. on III
							III	IV	V	VI		
										base	ung.	
1	2.61	3.81	1.00	0.50	0.15	0.17	0.98	0.81	0.62	0.21	0.90	12 and 12
2	2.43	3.68	0.95	0.43	0.14	0.17	0.94	0.79	0.58	0.22	0.86	11 and 11
3	2.34	3.24	0.90	0.43	0.14	0.20	0.73	0.73	0.51	0.18	0.81	9 and 7
4	1.78	2.96	0.88	0.40	0.13	0.14	0.70	0.63	0.48	0.18	0.82	6 and 3

Material: Four specimens on *Chrysanthemum parthinifolium*, May, 1959, Heliopolis, Cairo (author's collection).

Neotoxoptera viola Pergande

ALATE VIVIPAROUS FEMALE (Fig. 2): General colour brown.

Microscopical characters: Frontal tubercles well developed, converging and protruding inwards. Triommatidion present. Antennal hairs very short (10 μ). Secondary rhinaria on 3rd antennal segment circular and variable in size, averaging 17 and ranging 7-24; on 4th absent except one specimen showed one rhinaria on each of the left and right segment. Antennal formula 6-3-4-5; unguis about 3.8 times as long as the basal part. Apical rostral segment blunt with 8 secondary hairs. Veins of fore and hind wings bordered with a fuscous margin; M of fore wing twice branched; hind wing with two oblique veins. First hind tarsal segment with 3 hairs. 1st and 7th abdominal tubercles absent; 1st and 2nd abdominal spiracles close together and bordered with a pigmented area; dorsal abdominal patch present; lateral abdominal sclerites present with short hairs (10 μ); ante- and postsiphuncular sclerites present; 7th and 8th tergites also present. Siphunculi long and distinctly swollen at the distal half, without imbrications; apical flange present and distinct. Cauda elongate bearing 6 hairs.

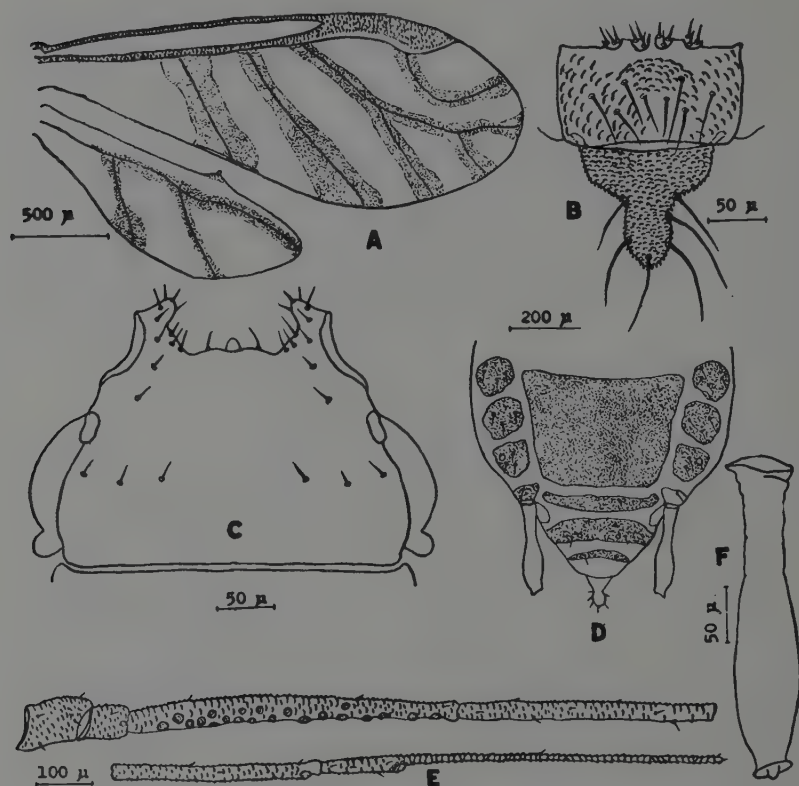


FIG. 2: *Neotoxoptera violae* Pergande (alata): A, fore and hind wings; B, anal plate and cauda (ventral view); C, head (dorsal view); D, abdomen (dorsal view); E, antenna; F, siphunculus.

Measurements in mm.:

No.	Length of body	Ant.	Siph.	Cauda	Apical rostr. seg.	2nd hind tarsus	Antennal segments					No. Rhin. on III
							III	IV	V	VI		
										base	ung.	
1	1.76	2.35	0.28	0.14	0.11	0.11	0.59	0.46	0.39	0.15	0.56	7 and 8
2	1.65	2.30	0.28	0.12	—	0.11	0.56	0.46	0.37	0.15	0.58	24 and 18
3	—	2.33	0.29	0.14	0.12	0.11	0.58	0.44	0.40	0.14	0.59	24 and 23
4	1.65	2.34	0.30	—	0.12	0.11	0.58	0.45	0.37	0.16	0.58	12 and 15

NOTA BENE: Slide no 2, only, showed a single rhinaria on 4th segment on each left and right segment.

Material: Four specimens on *Viola*, September 1958, Heliopolis, Cairo (author's collection).

The aphids live on the young shoots of *Viola* growing in the shade and the adults drop off the plant when much disturbed.

***Paczoskia turanica* (Nevskii)**

ALATE VIVIPAROUS FEMALE (Fig. 3):

Microscopical characters: Frontal tubercles well developed and diverging. Antennal hairs short (33 μ); secondary rhinaria circular, protruding and variable in size, present only on 3rd segment and ranging 64-68. Antennal formula (6-3)-4-5; unguis about 4.6 times as long as the basal part. Apical rostral segment very

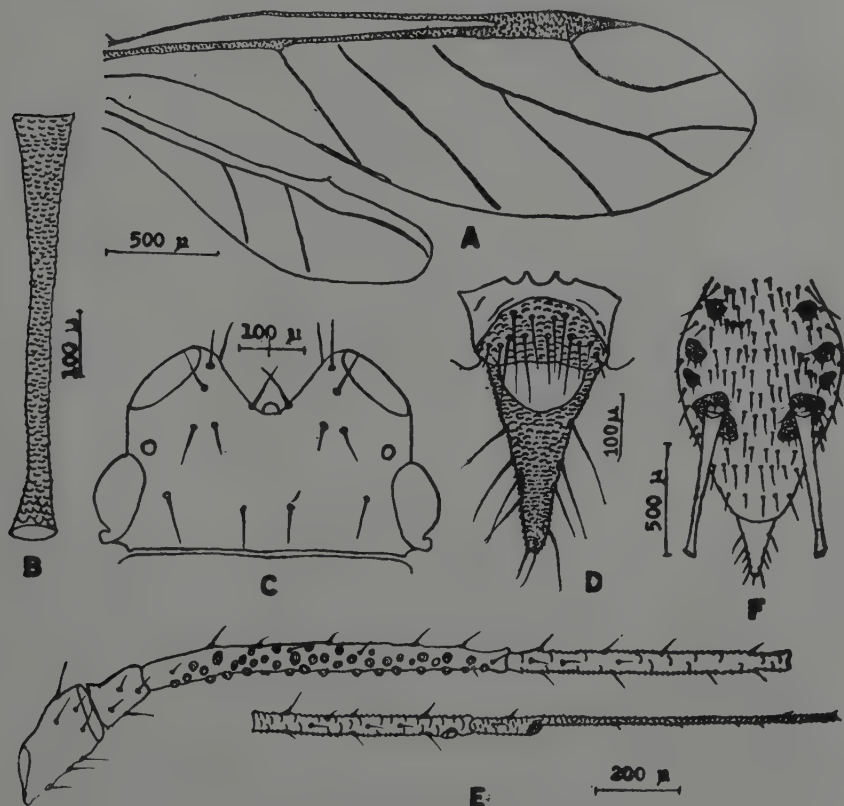


FIG. 3: *Paczoskia turanica* (Nevskii), alata: A, fore and hind wings; B, siphunculus; C, head (dorsal view); D, anal plate and cauda (ventral view); E, antenna; F, abdomen (dorsal view).

long and thin bearing a great number of secondary hairs (12) which are not even half as long as the ventral hairs of the body. Genus *Paczoskia* is best characterised by this unusual apical rostral segment (HILLE RIS LAMBERS, 1954). Wing venation normal; fore wing with M twice branched; hind wing with both M and Cu present. First tarsal segments with 5 hairs. Abdomen, clothed with hairs (44 μ) without abdominal scleroties at their bases. Abdominal tubercles absent; 1st and 2nd abdominal spiracles close together. Lateral sclerites small with hairs; ante- and postsiphuncular sclerites present. Siphunculi cylindrical, long, darkly sclerotised, imbricated and terminally dilated. Cauda triangular bearing 10 hairs.

Measurements in mm.:

No.	Length of body	Ant.	Siph.	Cauda	Apical rostral seg.	2nd hind tarsus	Antennal segments					No. Rhin. on III
							III	IV	V	VI		
										base	ung.	
1	2.37	3.19	0.68	0.30	0.26	0.13	0.87	0.67	0.52	0.15	0.70	64 and 68

Material: One specimen caught on a light trap in November 1958, Koubba Palace.

SUMMARY

The writer contributes to his previous survey of Aphididae of Egypt, the descriptions and illustrations of: (a) *Macrosiphoniella parthinii* (apterous viviparous female) as a new species; (b) *Neotoxoptera violae* Pergande and *Paczoskia turanica* (Nevskii) (alate viviparous females) as new records.

ACKNOWLEDGMENTS

The writer is grateful to Professor A.A.G. HASSAN, head of the Department and Vice-Dean of the Faculty, for offering facilities throughout the work. Thanks are also due to Professor A. HABIB for reading and correcting the manuscript and to Dr. V.F. EASTOP of the British Museum (Natural History) for identifying the specimens.

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-

1. The first part of the paper is devoted to the study of the properties of the function $f(x)$ defined by the equation $f(x) = \int_0^x f(t) dt$. It is shown that $f(x)$ is a constant function, and its value is determined by the initial condition $f(0) = 1$.

2. In the second part, we consider the function $g(x)$ defined by the equation $g(x) = \int_0^x g(t) dt$. It is shown that $g(x)$ is a constant function, and its value is determined by the initial condition $g(0) = 1$.

3. The third part of the paper is devoted to the study of the properties of the function $h(x)$ defined by the equation $h(x) = \int_0^x h(t) dt$. It is shown that $h(x)$ is a constant function, and its value is determined by the initial condition $h(0) = 1$.

4. In the fourth part, we consider the function $k(x)$ defined by the equation $k(x) = \int_0^x k(t) dt$. It is shown that $k(x)$ is a constant function, and its value is determined by the initial condition $k(0) = 1$.

5. The fifth part of the paper is devoted to the study of the properties of the function $l(x)$ defined by the equation $l(x) = \int_0^x l(t) dt$. It is shown that $l(x)$ is a constant function, and its value is determined by the initial condition $l(0) = 1$.

6. In the sixth part, we consider the function $m(x)$ defined by the equation $m(x) = \int_0^x m(t) dt$. It is shown that $m(x)$ is a constant function, and its value is determined by the initial condition $m(0) = 1$.

7. The seventh part of the paper is devoted to the study of the properties of the function $n(x)$ defined by the equation $n(x) = \int_0^x n(t) dt$. It is shown that $n(x)$ is a constant function, and its value is determined by the initial condition $n(0) = 1$.

8. In the eighth part, we consider the function $o(x)$ defined by the equation $o(x) = \int_0^x o(t) dt$. It is shown that $o(x)$ is a constant function, and its value is determined by the initial condition $o(0) = 1$.

9. The ninth part of the paper is devoted to the study of the properties of the function $p(x)$ defined by the equation $p(x) = \int_0^x p(t) dt$. It is shown that $p(x)$ is a constant function, and its value is determined by the initial condition $p(0) = 1$.

10. In the tenth part, we consider the function $q(x)$ defined by the equation $q(x) = \int_0^x q(t) dt$. It is shown that $q(x)$ is a constant function, and its value is determined by the initial condition $q(0) = 1$.

POPULATION STUDIES ON THE BLACK SCALE *CHRYSOMPHALUS FICUS* ASHMEAD

III. THE BUILD UP OF THE POPULATION ON DIFFERENT KINDS OF CITRUS

[Homoptera: Coccoidea]

EXD

(with 7 Text-Figures)

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INTRODUCTION

The writers in two previous papers, have dealt with the study of the population of this insect on its primary host, *Ficus nitida*.

Some observations on the build up of population on different kinds of citrus were given by several authors but no detailed study was carried out. BODKIN (1925) stated that all species of citrus are equally liable to attack; but it is interesting to note that the bitter orange, used as a stock, is inclined to be resistant to this pest. PRIESNER (1931) reported that, in Egypt, lemon baladi is the most resistant (less attacked), while Adalia lemon is the most susceptible (heavily attacked). He also stated that sweet lemon is never heavily infested. SCHWEIG and GRUNBERG (1936) stated that all kinds of citrus trees suffer from infestation with the black scale; but the following order of preference may be taken as characteristic of the Jordan Valley: grapefruit, orange, mandarin and lemon. In the Acre region the relative degree of infestation may be indicated as follows: Orange, lemon and mandarine (no grapefruit is cultivated there).

It has been shown by De TOLEDO (1940) that *Chrysomphalus ficus* sometimes causes young citrus trees to lose their leaves and suffer visible retardation of growth

and that it is less common on older fruit-bearing trees. MASON (1946) stated that during 1944-1945 *Chrysomphalus ficus* was the major pest of *Citrus* and some groves suffered from wide spread, and may ultimately die as a result of the attack. OSBURN and MATHIS (1946) found out that their investigations in Florida, in 1942-1944, confirmed an observation made in 1941, which showed that *Chrysomphalus ficus* Ashm. becomes more numerous on cultivated orange trees than on uncultivated ones in the same grove because cultivated trees were more vigorous and in better physical condition than those left uncultivated, even though they were more heavily infested. They concluded that tree stimulation as a result of cultivation was the most important factor in the development of the infestation. The writers observed that the crawlers always prefer new leaves to old leaves to settle on.

MARTIN (1954) observed that *Chrysomphalus dictyospermi* (Morg.) mainly attacked orange and mandarin orange, and was rare on grapefruit and lemon.

These observations drew the writers' attention to make a detailed study on the build up of population on different kinds of citrus aiming to conclude their different degrees of susceptibility.

MATERIAL

Observations were carried out in an orchard (about five feddans), at Mustorod, containing 770 trees of citrus belonging to 28 species and varieties. No adequate control was ever carried out in that orchard.

A large scheme experiment was carried out for the study of the build up of the population on different kinds of citrus. Fifty four citrus trees belonging to nine species and two genera (6 from each species) were brought from Korashiia in early February 1957. The different grafts used are tabulated below:

Sweet orange (*Citrus sinensis* var. *sukkari*); Navelencia lale (*Citrus sinensis* var. Egyptian); Mandarine baladi (*Citrus reticulata* Blanco); Kumquat (*Fortunella margarita* Swing.); Adalia lemon (*Citrus Limon* Linn.); Grapefruit (*Citrus grandis* (Linn.); Red blood orange (*Citrus sinensis* (Linn.) var. Egyptian blood); Orange baladi (*Citrus sinensis* (Linn.) var. *baladi*); Lemon baladi (seed) (*Citrus aurantifolia* Swing.).

NOTA BENE: (1) The stock for the above grafts was always Sour orange (*Citrus aurantium* Linn), except for Kumquat, where it was Lemon baladi (*Citrus aurantifolia* Swing.); (2) Sour orange was not available as a graft at the beginning of the experiment and was cultivated later (No. 10).

The trees were about two years old and free from infestation. They were cultivated in pots (40 cm. diameter) till February 1958. At the end of February, the trees were transferred to be cultivated at Mustorod in 2.5 × 3 metres. in Rundamised complete blocks. The orchard was surrounded by arable fields and very far from any source of infestation.

TECHNIQUE

With regard to the observations carried out in the previously mentioned orchard it was found more convenient to give the symbols; free, light, moderate, moderate to heavy and heavy to the different degrees of infestation.

As for the experiment, several attempts were carried out for inducing artificial infestation to the potted plants. They consisted of the following methods:

(a) Spreading newly hatching crawlers; (b) tying an infested branch of *Ficus retusa* to one of the branches of the tree; (c) applying a certain number of infested leaves of *Ficus retusa* to each tree.

In most cases the crawlers, although succeeding to settle and secreting the white caps, yet they always failed to continue surviving and the infestation never flourished. This was attributed to the bad agricultural conditions prevailing the plants in their pots. The root system of the plants were definitely abnormal, the irrigation was not natural and defoliation of the trees was very frequent. This condition necessitated the transfer of the plants to the soil.

However these attempts were useful in pointing out the most successful method inducing artificial infestation. It was found to be the third above mentioned method, i.e. applying a certain number of infested leaves.

At the beginning of November the trees were thoroughly cleaned from insects and carefully washed with water. They were examined on the 4th of February and were found to be completely free from infestation.

On the 8th of March 1958 the trees were transferred to the soil and were cultivated at Mustorod in Rundamised Complete Blocks (R.C.B.) according to the following chart.

NORTH

B VI	B V	B IV	B III	B II	B I
9	1	2	8	4	5
3	10	6	10	5	8
1	5	9	7	6	4
5	4	3	6	9	7
8	3	10	4	7	6
10	9	5	1	2	10
6	8	7	5	3	9
4	6	1	3	10	2
2	7	8	2	8	1
7	2	4	9	1	3

The distance between each two blocks was 3 metres, and between each two trees was 2.5 metres.

On the 15th of March the trees were examined and found to be free from infestation.

Twenty leaves of *Ficus retusa* heavily infested with *Chrysomphalus ficus* were applied to each tree. This was carried out by cutting the leaf of *Ficus* at its mid-rib in the middle of the blade and fixing it to a leaf of citrus at the end of a branch. The infested leaves were uniformly distributed on each tree. On the 20th of March many crawlers succeeded to settle. On the 12th of April the inner red zone appeared, while the outer red zone in females and the black oval zone in males appeared on the 28th of April. On the 8th of May some adult males appeared. On the 11th of May females could be seen in different stages of growth. Some were seen to acquire their black zone while others were still in the stage of the outer red zone.

A very careful counting of the insects was carried out during the four generations. Two counts were carried out in each generation. The 1st count included the number of infested leaves, total number of insects, number of females, number of males and number of indifferentiated individuals (in the 1st generation all the individuals could be differentiated to males and females). In the 2nd count it was found sufficient to estimate the number of mature adult females (which completed the black zone) and the leaves they infest, since they are regarded as the source of infestation in the proceeding generations.

The sour orange (No. 10) was not available at the beginning of the experiment. It was cultivated on the 17th of April by the same way. Counting on this species was thus carried out once only, i.e. the second count of the 4th generation, and thus it was not included in the statistical analysis. It was used merely later in a comparative way.

ANALYSIS OF RESULTS

For studying the susceptibility of different kinds of citrus to infestation with the Black scale the following scheme of statistical analysis was carried out:

(1) The data obtained in each count were subject to a simple analysis of variance. The criteria analysed in the 1st count were numbers of infested leaves, total number of insects, females, males, and indifferentiated individuals. Those analysed in the 2nd count in each generation were numbers of mature adult females (which completed the black zone) and of leaves they infest.

(2) The totals for each criterion were taken for the whole experiment, i.e. for the four successive generations and were subject for another analysis of variance. The following symbols were given to show the different degrees of significance:

* for F values significant to the level of 20%; ** for F values significant to the level of 5%; *** for F values significant to the level of 1%; **** for F values significant to the level of 0.1%.

(3) When the results of analysis showed to be significant at 5% level of significance the least significant difference (L.S.D.) was estimated to separate differing criteria.

(4) If the above estimation of L.S.D. failed to separate between successive means of kinds arranged in order of magnitude, a careful sub-analysis using TUKEY's formula was carried out (TUKEY, 1949).

Curves were drawn to illustrate the above mentioned criteria in the used different kinds of citrus.

RESULTS

A. Observations carried out in an orchard at Mostorud.

This orchard, as previously mentioned, contained 28 different kinds of citrus represented in 770 trees. The trees were classified according to their degree of infestation and were found to follow the following order.

Free: *Citrus aurantifolia* Swing. varieties baladi, rabeey, agami, and mes-tekawy.

Light: *Citrus sinensis* (Linn.) varieties Egyptian, khalili and valencia; *Citrus medica*; *Citrus limon* Linn. var. Palestine sweet (sweet lemon) and *Citrus aurantifolia* Swing. var. sweet (sweet lime).

Moderate: *Citrus limon* Linn.; *Citrus limon* var. kabbad; *Citrus reticulata* Blanco varieties satsuma, clementine, baladi and cleopatra; *Citrus sinensis* (Linn.) varieties sukkari, Soliman pasha and Jaffa; *Citrus grandis* (Linn.) (shaddock); *Fortunella margarita* Swing.; *Citrus Aurantium* Linn. and *Citrus aurantium* sub-species *bergamia* (Risso and Poit.) (bergamot).

Moderate to heavy: *Citrus limon* Linn. var. rough and *Citrus grandis* (Linn.).

Heavy: *Citrus Limon* Linn. var. naffash and *Citrus sinensis* (Linn.) varieties baladi and Egyptian blood.

B. Experiment carried out on artificially infested 10 kinds of citrus.

Counts were carried out twice in each generation and were continued for four successive generations.

The F values obtained for the four generations are given here after.

It is clear from the previously given tables of F values, that the results were never significant to the level of 5% except in one case, i.e. the number of males of the second generation.

This fact was attributed to the high individual differences in each kind causing the enlargement of the error. This fact however may be of utmost economic importance in breeding and selecting new varieties of citrus which may be totally immune to infestation with this insect.

FIRST GENERATION

Source of variance	F Blocks	F Species
Number of leaves 1st count	0.414	2.050*
Total number of insects	1.095	1.299
Number of females	1.291	0.945
Number of males	0.810	1.772*
Number of leaves 2nd count	0.881	1.521*
Number of mature females	1.433	1.149

SECOND GENERATION

Source of variance	F Blocks	F Species
Number of leaves 1st count	0.574	2.059*
Total number of insects	1.184	2.060*
Number of females	0.979	2.458*
Number of males	0.923	2.519**
Number of indifferntiated individuals	2.148*	1.315
Number of leaves 2nd count	0.511	1.170
Number of mature females	0.758	1.802*

THIRD GENERATION

Source of variance	F Blocks	F Species
Number of leaves 1st count	0.476	1.524*
Total number of insects	0.756	1.416
Number of females	0.623	1.472*
Number of males	0.700	1.365
Number of indifferntiated individuals	1.661*	1.387
Number of leaves 2nd count	0.382	1.502*
Number of Mature females	0.566	1.351

FOURTH GENERATION

Source of variance	F Blocks	F Species
Number of leaves 1st count	0.276	1.861*
Total number of insects	0.725	1.607*
Number of females	0.784	1.571*
Number of males	6.671	1.479*
Number of indifferntiated individuals	0.780	1.659*
Number of leaves 2nd count	0.433	1.915
Number of mature females	0.688	1.620*

For the case of the number of males in which the F value was significant to the level of 5% the second step of analysis, i.e. the estimation of L.S.D. was carried out. The results were subject to separation according to the L.S.D. and according to Tukey's formula and did not provide evidence to be separable into different groups.

These results however do not throw light on the build up of the population. For giving a clear picture about the build up of the population, it was found more convenient to carry out a statistical analysis for the different criteria in the whole experiment i.e. comparing between the four successive generations. The criteria analysed in this case were numbers of infested leaves (1st count), total number of insects, females, males, indifferentiated individuals, infested leaves (2nd count) and mature adult females.

The usual method of analysis of variance was adopted.

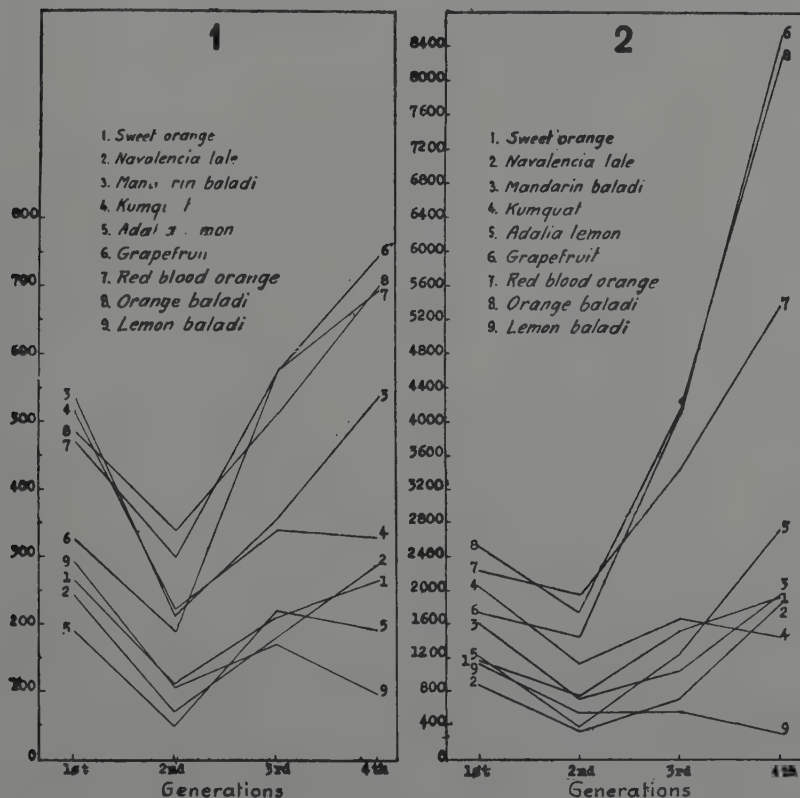


FIG. 1: Number of infested leaves in first count. — FIG. 2: Total number of insects.

It is worth mentioning that for the test of significance, the interaction between kinds and generations is tested against the residual. If the interaction is not significant it is pooled with the residual and a new mean square is obtained. This new mean square is used for testing the main factors, i.e. the kinds and the generations.

Whenever the results proved to be significant they were tested again according to the L.S.D. and to TUKEY's formula for separating them to different groups. The final results of the different used criteria were as follows:

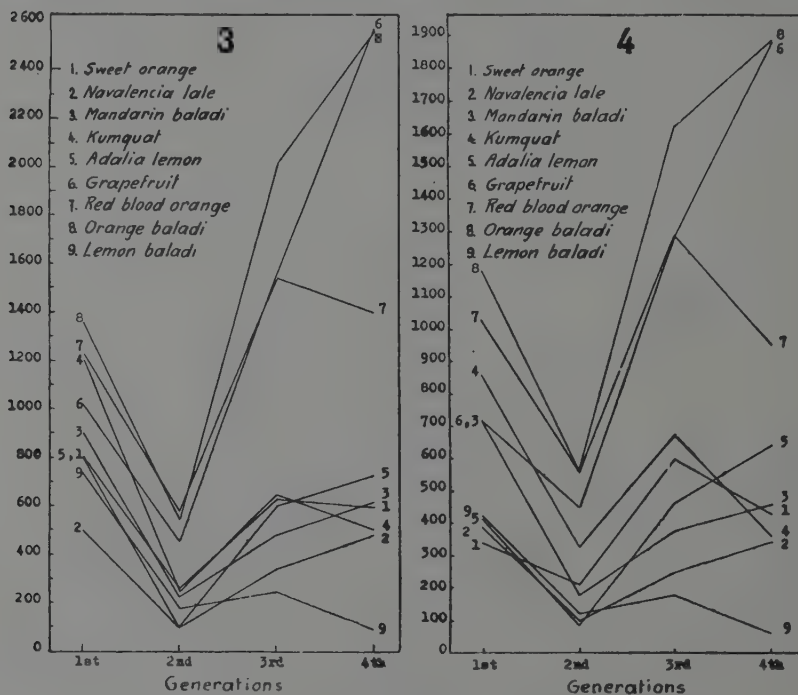


FIG. 3: Number of females. — FIG. 4: Number of males.

1. — Number of infested leaves (1st count) (Fig. 1).

The kinds were separable to the following groups:

GROUP I: lowest number of infested leaves, include Adalia lemon and lemon baladi.

GROUP II: Moderate number of infested leaves, include Navalencia lale, sweet orange, kumquat, mandarin baladi and grapefruit.

GROUP III: highest number of infested leaves, include orange baladi and red blood orange.

2. — *Total number of insects* (Fig. 2).

The kinds were separable to the following groups:

GROUP I: moderate number of insects, include lemon baladi, Navalencia lale, sweet orange, mandarin baladi, Adalia lemon and kumquat.

GROUP II: highest number of insects, include red blood orange, grapefruit and orange baladi.

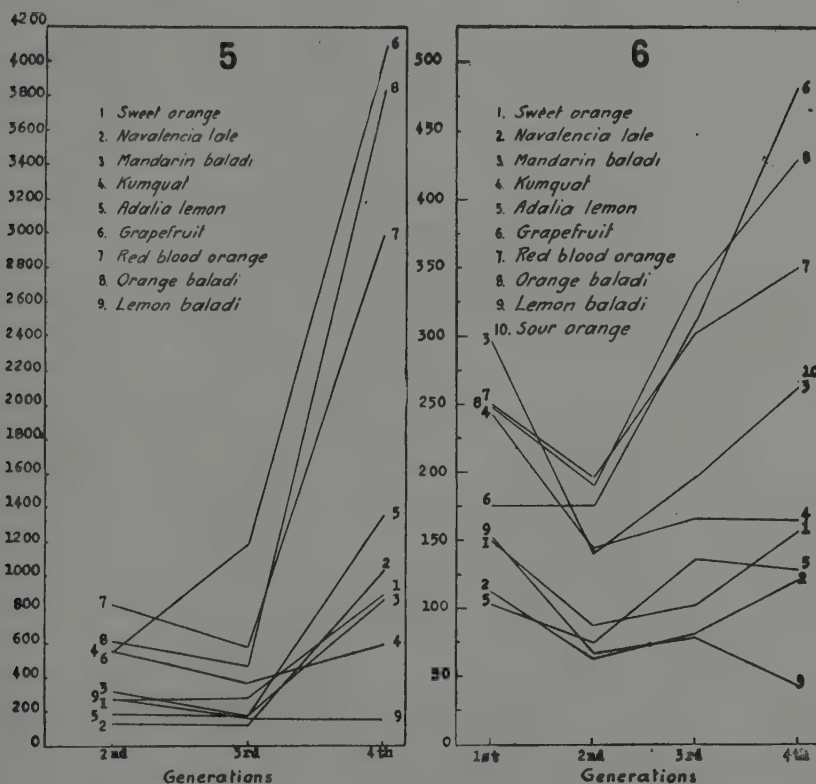


FIG. 5: Number of undifferentiated individuals. — FIG. 6: Number of infested leaves in second count.

3. — *Number of females* (Fig. 3).

The kinds were separable to the following groups:

GROUP I: moderate number of females, include lemon baladi, Navalencia lale, mandarin baladi, Adalia lemon, sweet orange and kumquat.

GROUP II: highest number of females, include red blood orange, grapefruit and orange baladi.

4. — *Number of males* (Fig. 4).

The kinds were separable to the following groups:

GROUP I: moderate number of males, include lemon baladi, Navalencia lale, sweet orange, Adalia lemon, mandarin baladi and kumquat.

GROUP II: highest number of males, include red blood orange, grapefruit and orange baladi.

5. — *Number of indifferentiated individuals* (Fig. 5).

The kinds were separable to the following groups:

GROUP I: moderate number of indifferentiated individuals, include lemon baladi, Navalencia lale, mandarin baladi, sweet orange, kumquat, Adalia lemon and red blood orange.

GROUP II: highest number of indifferentiated individuals, include orange baladi and grapefruit.

6. — *Number of infested leaves* (2nd count) (Fig. 6).

The kinds were separable to the following groups:

GROUP I: lowest number of infested leaves, include lemon baladi.

GROUP II: moderate number of infested leaves, include Navalencia lale, Adalia lemon, sweet orange, kumquat and mandarin baladi.

GROUP III: highest number of infested leaves, include red blood orange, grapefruit and orange baladi.

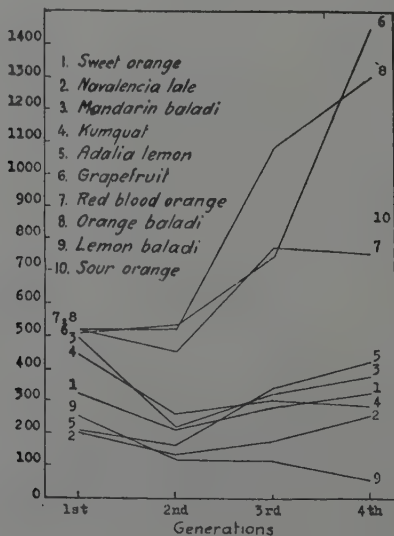


FIG. 7: Number of mature adult females.

7. — *Number of mature adult females* (Fig. 7).

The kinds were separable to the following groups:

GROUP I: moderate number of mature adult females, include lemon baladi, Navalencia lale, Adalia lemon, sweet orange, kumquat and mandarin baladi.

GROUP II: highest number of mature adult females, include red blood orange, grapefruit and orange baladi.

With regard to Sour orange, it was cultivated as previously mentioned much later than the other kinds (17th of April) and thus it was not possible to introduce it among other kinds in the analysis of variance. It was subject to counting once only, i.e. in the second count of the 4th generation. Data obtained from it were as follows: mean number of infested leaves per tree=45 ranging from 5 to 128; mean number of mature adult females per tree=141 ranging from 13 to 464.

When roughly comparing these data with the data obtained for the other kinds of citrus, it was clearly seen that sour orange when compared according to the number of females, falls in the group of highly infested kinds, while it falls inbetween the moderately and heavily infested groups when compared according to the number of its infested leaves (Figs. 7 and 6, respectively).

SUMMARY

Several attempts had been carried out by some authors, e.g. BODKIN (1925), PRIESNER (1931) and SCHWEIG and GRUNBERG (1936), to study the population of this insects on different kinds of citrus. Their conclusions however were mainly based on mere observations. No experimental study was ever carried out.

The writers' conclusions are based on both observations and experimental work.

(a) The observations carried were out in an orchard at Mustorod containing 770 trees comprising 28 different kinds of citrus. They have proved to be differently susceptible and could be classified into five groups namely free, light, moderate, moderate to heavy and heavy.

(b) The experimental part of the work consisted of cultivating 10 different kinds of citrus in randomised complete blocks. They were free from infestation and were artificially infested by insects collected from *Ficus retusa*.

The conclusions arrived at confirmed to a great extent the observations carried out at Mustorod. There was a significant difference between the different kinds in all the criteria used. There was a noticeable drop in the 2nd generation in nearly all the used kinds. This was attributed to the fact that a certain number of individuals which could succeed to settle after the artificial infestation, could not survive and continue through the next generation.

The results obtained from this part of the work led to the fact that these kinds can easily be classified according to their susceptibility into the following groups:

Resistant: Lemon baladi.

Moderate: Navalencia lale, sweet orange, Adalia lemon, kumquat, and mandarin baladi.

Moderate to havy: Sour orange.

Heavy: Red blood orange, grapefruit and orange baladi.

It is worth mentioning that there is a noticeable drop in the population of *Chrysomphalus ficus* Ashmead nowadays in all the citrus orchards allover Egypt. There are different views in explaining this phenomenon. Some entomologists attribute this drop to the activity of certain parasites, while others attribute it to the effect of successive fumigation of the trees year after year.

The writers however are more inclined to the second view and this inclination is based on the following conclusions:

(a) The presence of a very high population in certain orchards of citrus which were left without treatment.

(b) The presence of a very high population of this insect on its primary hosts, e.g. *Ficus* sp.

(c) The fact that there is a significant difference between generations in statistical analysis carried out for the experimental part, together with the clear build up of the population from one generation to the next support this view. No such difference or growth in population could ever be noticed if the reason was due to the activity of parasites.

However strong the evidences are, yet the cause of the drop of the population of this insect on citrus in Egypt nowadays needs further investigations.

An interesting conclusion which needs not to be ignored is the great individual differences recorded in some of the used kinds of citrus. This fact is very economically important and if carefully studied from the genetical point of view may lead to the production of certain races which may be immune to infection with this insect.

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A CONTRIBUTION TO THE STUDY ON THE FLIGHT ACTIVITY OF THE HONEYBEE

[*Hymenoptera: Apidae*]

(with 6 Text-Figures)

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The present investigations were carried out to study the effect of the temperature and the relative humidity on the flight activity of the three standard races; Carniolan, Caucasian and Italian honeybees. It is well known that the flight activity of the honeybee depends on the nectar flow of flowers in the field and the different environmental conditions. It was found by different investigators that the climatic conditions have unequal effect on the different plant species and the honeybee foraging. The present studies were carried out during the flowering seasons of citrus, clover and cotton.

REVIEW OF LITERATURE

HAMBLETON (1925) found a positive correlation between the daily net gain and both the solar radiation and the average temperature. A negative correlation was found between the net gain and the relative humidity.

LUNDIE (1925) secured a large amount of valuable data on flight activities of the honeybee through the use of a mechanical device. He stated that storms and winds reduce the possible maximum flight by an amount that varies according to the wind's duration. He also added that a strong colony commences flight at a lower temperature than does a weak one.

BODENHEIMER (1937) arrived to some interesting conclusions which can be summarized as follows:

(1) No activity was observed below 8°C.; (2) from 9 to 16°C. the average flight activity was below its normal level; (3) the optimal range of activity seemed

to be within the range of 16 and 32°C.; (4) a reduction of activity occurred at 33°C.; (5) a high rise in bee activity was observed between 34 and 39°C., this may be attributed to feverish water-transport.

BEUTLER (1953) stated that high relative humidity increases the nectar in the flowers. He found that the main secretion of sugar, in lime, frequently occurs at nights with low temperature. However, many other investigators have shown that various plant flowers differ markedly in their optimum secretory periods.

MOFFETT and PARKER (1953) found that over 58% of the nectar was stored at a maximum daily temperature range of 85-94°F.(about 30-34°C.); 10% at/or over 100°F. (about 38°C.), but only 3.3 % was stored below 80°F. (about 27°C.). They also added that the optimum daily temperature range for a good nectar-flow varied during the different months, due to the difference in the plants blooming at the time.

Wafa (1954) concluded that a highly significant correlation coefficient exists between the degree of bee activity and changes in the colony weight. Low temperature has been found to have a direct effect on retarding the gain of the colony and shortening the period of flight. A highly significant positive correlation coefficient was found between the maximum temperature and the number of hours of flighting. He also noticed that dry atmosphere increased the colony weight and prolonged the duration of the period of flighting.

HASSANEIN and EL-BANBY (1958) reported that the Carniolan bee did more daily trips than both the Italians and the Caucasians, during the flowering seasons of citrus and cotton, while the Italians were more active on clover blooms. They also found that the number of daily expeditions done by the Carniolan bee to cotton flowers was higher than those done to citrus or clover blooms. On the other hand, the Italian and Caucasian bees showed more activity in foraging on clover flowers. However, the Caucasian bees have done the least number of trips during all seasons.

METHOD AND TECHNIQUE

Seventy workers of each of the three experimental races, were individually marked, just after emergence, and were introduced together in one colony. Observations were carried out after the commencement of foraging for a period of four days, during each of the three flowering seasons (from sunrise to sunset). The time of exit and return for each bee was recorded. Hourly records for the temperature and relative humidity were also taken, throughout the observation periods. The relationship between the hourly means of temperature and relative humidity, and the hourly percentages of trips made by the workers, during the blooming season of citrus trees, were represented in the form of regression lines or correlation coefficients. In order to eliminate the hourly variation, each day was divided into 5

periods; (1) before 8 a.m.; (2) between 8 and 10.59 a.m.; (3) between 11 and 1.59 p.m.; (4) between 2 and 4.59 p.m.; and (5) after 5 p.m.

RESULTS

Figures 1, 2 and 3 show the hourly percentages of expeditions and the hourly means of temperature and relative humidity, during the three main flowering seasons.

It appears from Fig. 4 and Table I that the Caucasian bees started foraging later in the morning, while the Carniolans were the earliest in foraging, during

TABLE I

The percentages of expeditions flown by the workers of the three races, throughout the five periods of the day, during the three flowering seasons.

Seasons	Periods of day	Mean temp. in °C.	Mean R.H. %	Percentages of expeditions		
				Cauc.	Ital.	Carn.
Citrus	before 8 a.m.	13.6	83.8	12.7	18.4	19.8
	8 — 10.59	15.4	62.0	36.7	44.9	45.1
	11 — 1.59 p.m.	23.5	36.0	20.6	11.5	15.6
	2 — 4.59	25.5	25.5	26.7	23.1	17.7
	after 5	24.3	26.7	3.7	2.0	1.8
Clover	before 8 a.m.	21.0	79.5	16.2	18.7	18.5
	8 — 10.59	25.3	60.4	27.9	28.6	25.6
	11 — 1.59 p.m.	30.3	39.0	23.6	22.3	22.5
	2 — 4.59	32.2	30.1	29.5	27.7	31.3
	after 5	30.7	31.3	2.7	2.7	2.0
Cotton	before 8 a.m.	21.2	84.1	8.6	9.8	16.8
	8 — 10.59	25.6	63.5	21.7	29.3	30.4
	11 — 1.59 p.m.	30.2	40.5	20.4	26.8	23.7
	2 — 4.59	32.5	33.1	39.4	28.6	25.0
	after 5	32.0	34.7	9.9	5.5	4.1

L.S.D. at 5% level: for Periods = ± 0.654 ; for Races \times Periods = ± 1.33 ; for Seasons \times Periods = ± 1.133 ; for Races \times Seasons \times Periods = ± 1.965 .

the three flowering seasons. The three races decreased their flight activity at noon, during the different blooming seasons. This decrease was also noticed in the blooming season of citrus (the last half of March and April) when the sun heat, at noon, was relatively mild, than it was in the different periods of days in the other seasons. During the three seasons, the Italian bees showed more activity in the morning

than in the evening. The Caucasian bees were more active in the afternoons during the blooming seasons of clover and cotton. The variance between their morning and evening flight activities, in the citrus blooming season was less than that of the two other races. The Carniolan bees were more active in the morning on the citrus and cotton flowers, but showed more activity in the evening when clover was in bloom.

Statistical analysis of the data showed clearly that there was a highly significant difference between the periods, and the interactions between periods and both seasons and races.

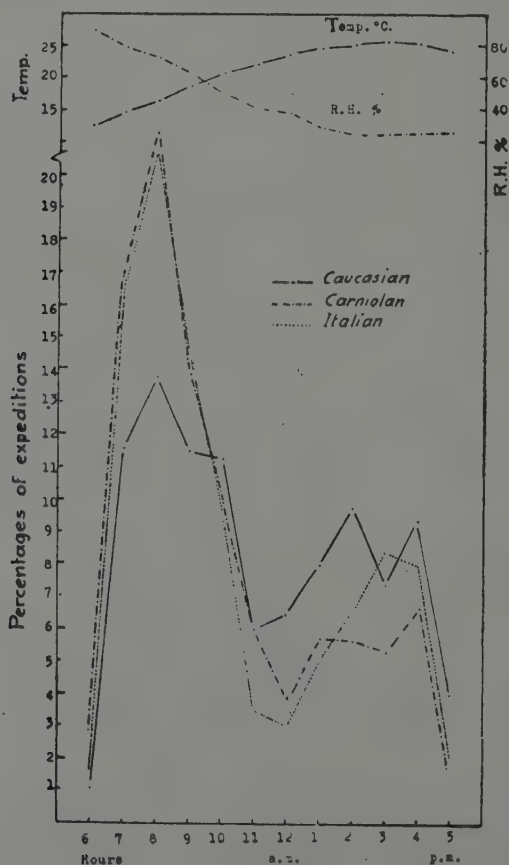


Fig. 1: Hourly percentages of expeditions, temperature and relative humidity, during the citrus honeyfleur.

Figure -5 shows that there was a significant negative correlation between the temperature and the flight activity of the three races, during the citrus blooming season. The regression coefficient was -0.5269 (in the case of Caucasian bees), -1.2919 (in the case of Italian bees) and -1.4214 (in the case of Carniolan bees).

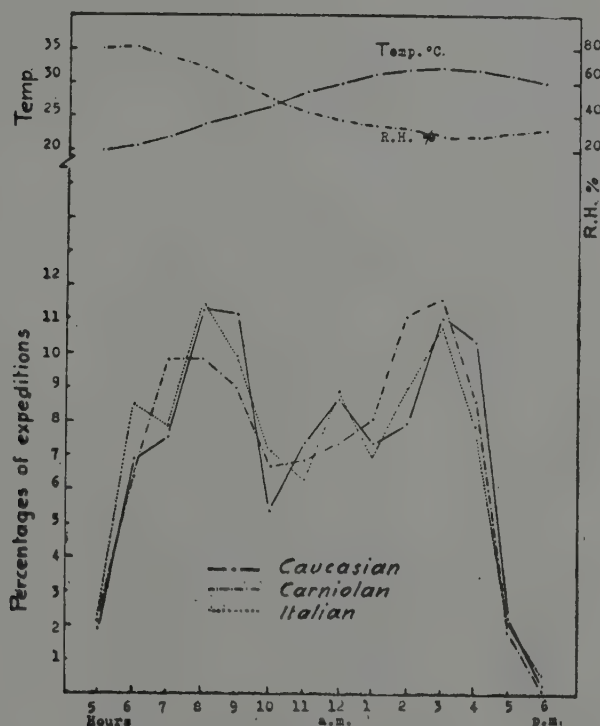


FIG. 2: Hourly percentages of expeditions, temperature and relative humidity, during the clover honeyflow.

Figure 6 shows a significant positive correlation between the relative humidity and the flight activity of the three races. The regression coefficient was + 0.1064 (for the Caucasians), + 0.2530 (for the Italians) and + 0.2760 (for the Carniolans).

The regression coefficients between the temperature (or relative humidity) and the flight activity of the Italian and Carniolan bees were insignificantly different, while those of the Caucasians were significantly less than those of the two other races.

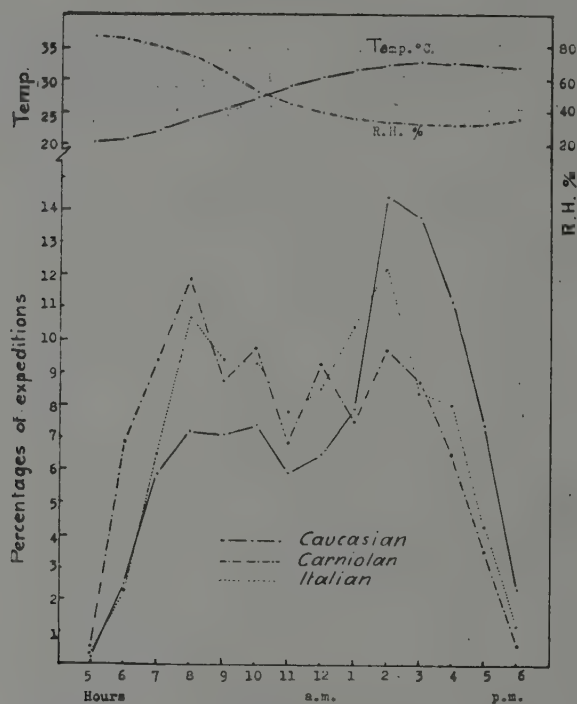


FIG 3: Hourly percentages of expeditions, temperature and relative humidity, during the cotton honeyflow.

CONCLUSIONS

From the above mentioned investigations, the following conclusions can be summarized:

- (1) The effect of both temperature and relative humidity on the flight activity of bees differs according to their race as well as to the different flowering seasons.
- (2) The flight activity of the different bees, always decreases at noon. This fact is also found in the blooming season of citrus, when the direct sun heat is relatively mild.
- (3) The three races preferred foraging on citrus flowers in the morning, and decreased their activity by the increase in temperature (and decrease in humidity). The rate of decrease in the flight activity of the Caucasian bees, was significantly less than in the case of the two other races.

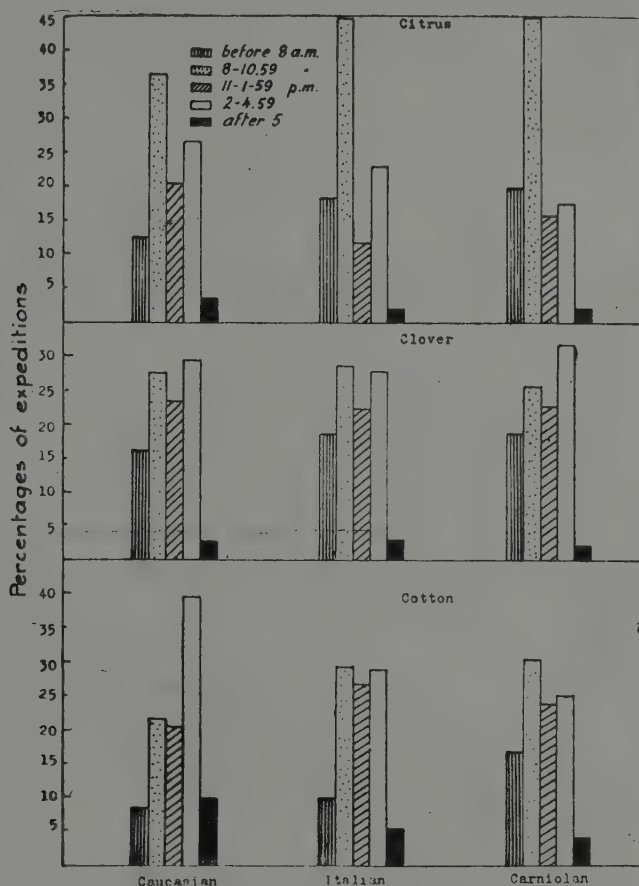


FIG. 4: Percentages of expeditions flown by the workers of the three races, during the five periods of the day.

(4) The more optimal condition for the flight activity of the three races during the citrus blooming season seems to be at about 16.5°C. and 72.7% R.H.; the utmost foraging was performed at these degrees (at 8 a.m.).

(5) It was noticed that the maximal flight activity, during the blooming season of clover was done at 8 a.m., when the mean temperature was 23.9°C. and the mean relative humidity was 69.2%. A reduction of activity occurred by the increase of temperature and decrease of humidity, but another rise of activity was observed when the temperature was higher than 32°C and the relative humidity was 33.5% (at 3 p.m.).

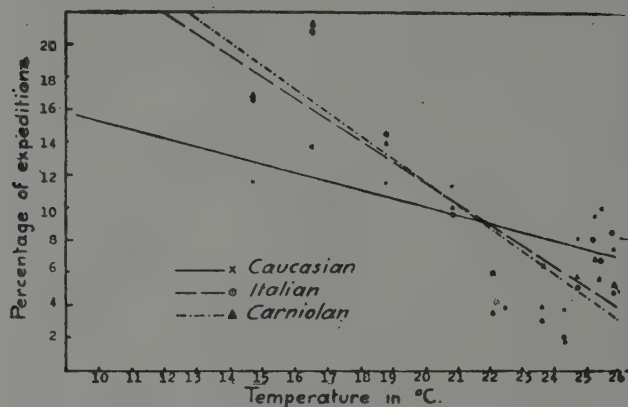


FIG. 5: Relationship between the percentages of expeditions and temperature, in the case of the three standard races, during the blooming season of citrus trees.

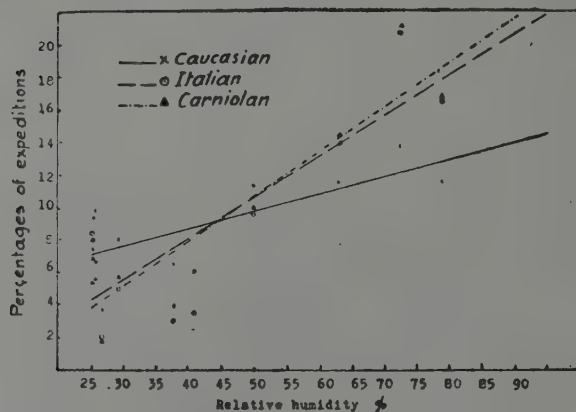


FIG. 6: Relationship between the percentages of expeditions and the relative humidity, during the blooming season of citrus trees.

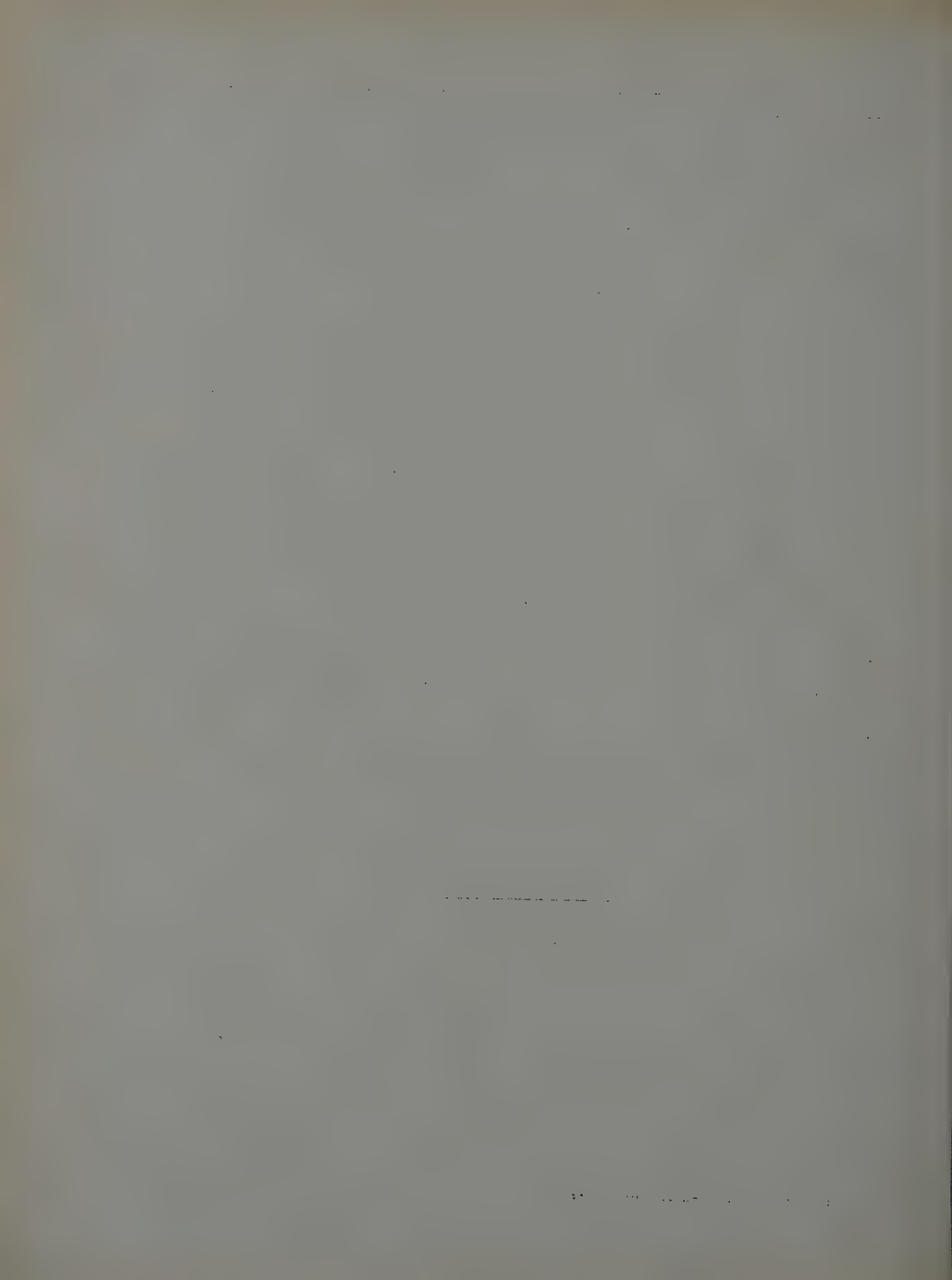
(6) The morning peak of flight activity, during the cotton blooming season, occurred at 8 a.m. when the mean temperature was 24°C. and the relative humidity was 74%. The flight activity decreased with rise of the temperature (and decrease in the relative humidity). At 2 p.m. a second peak was observed when the mean temperature reached 32.2°C. and the relative humidity was 34%.

(7) The Caucasian bees showed the highest flight activity in the warmest periods of the day (during the clover and cotton blooming seasons). The Italian

bees showed less tendency to increase their flight activity above 32°C., the largest numbers of expeditions were made in the mornings of the three flowering seasons. The Carniolan bees showed more activity in the afternoons, during the clover blooming seasons, while they were more active in the mornings of the citrus and cotton seasons.

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**SOIL MOISTURE IN RELATION TO PUPATION
AND MOTH EMERGENCE
OF THE COTTON LEAF WORM,
PRODENIA LITURA (FABR.)**

[*Lepidoptera: Noctuidae*]

E.M.M.

(with 5 Tables)

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INTRODUCTION

In a study conducted by HASSAN et al. (1960) on the distribution of the cotton leaf worm in Berseem fields, larvae were found to pupate in elevated areas as they avoided the relatively wet plane areas of the same field. In this paper the authors give the result of an investigation on the relationship between the soil moisture and the selection of the pupation site by the full grown larvae as well as the subsequent effects of the soil moisture on the pupal development and the rate of emergence.

Experiments were carried out in the laboratory of the Cotton Insects Investigation Section of the Ministry of Agriculture in Giza, during the year 1958.

MATERIALS AND METHODS

Laboratory experiments were made on the selection of the pupation site by the full grown larvae in relation to soil moisture. For this purpose, light clay soil was prepared to contain on weight basis 30, 20 and 10% moisture content. Air dried soil was used as control. Choice of gradients of moisture was based on the fact that the soil moisture ranges in the field from 10 to 30% between successive irrigations.

Soils representing the four treatments were placed in one large 16 mesh-screen wire cage ($1 \times 1 \times 1$ metre). Each treatment was put in one corner of the cage and apart from the others. Full grown larvae were then introduced into the center of the cage and left to choose freely the suitable soil for pupation. Examination of the differently treated soil took place after one week, and records were kept of the number of larvae or pupae found in each treatment. Four successive trials were made in which 44, 37, 26 and 99 larvae were used.

The subsequent effects of the different gradients of the soil moisture on pupal development and the rate of emergence of moths were also investigated. For this purpose four treatments of light clay soil with 30, 20 and 10 % moisture contents as well as air dried soil were prepared. Soil of each treatment was then put in one quarter-litre breakers and each was provided with a full grown larva about to pupate. Two sets of experiments each of four treatments were conducted in the laboratory. The soil moisture of one set was allowed to decrease by natural evaporation under room conditions while the moisture of the other set was maintained constant throughout the experiment. The latter was accomplished by daily weighing of each beaker and the addition of an amount of water equivalent to the loss due to evaporation.

Depths of pupal chambers, formed by full grown larvae, and the angles at which they lie in soil were obtained. Measurements were taken from the outside of the glass beakers because of their transparent walls. Records were also kept for dates of pupation and for those of moth emergence.

RESULTS AND DISCUSSION

(A) SELECTION OF PUPATION SITE. — Full grown larvae of the cotton leaf worm are less inclined to pupate in light clay soil with excessive moisture or in air dried soil. Approximately 68 % of the larvae used pupated in soil with 20 % moisture content. However, the percentage of larvae attracted to soil with 30 % moisture content and to air dried soil amounted to 8.3 and 4.4, respectively (Table I). In soil with 10 % moisture content about 18.9 % of the larvae pupated. This percentage of larvae is relatively high if compared with those of the air dried soil or the soil with 30 % moisture content.

(B) DEPTH AND POSITION OF PUPAL CHAMBER IN SOIL. — BISHARA (1934) found pupae at a depth of one or two inches below soil surface while WILLCOCKS and BAGHAT (1937) reported that pupal cells were very shallowly positioned, with the top of the cell almost at the surface of the soil or at a depth of only from a half to two cm. However, WIESMANN (1952) mentioned that in loose soil pupal chambers were generally laid at a maximum depth of 2 cm., whereas in hard soil they were found only about 1 cm. deep.

Soil moisture delimits the depth at which the full grown larvae pupate. Examination of soil with different gradients of moisture showed that in dry soil, larvae

TABLE I

Selection of suitable soil for pupation by full grown larvae of Prodenia litura, in laboratory (Mean temp. 29°C.)

Number of trial	Number of larvae used	Number of larvae attracted to soil with different moisture contents			
		Moisture			
		Air dried	10%	20%	30%
I.	44	5	2	32	5
II.	37	0	17	18	2
III.	26	0	1	23	2
IV.	99	4	19	68	8
Total	206	9	39	141	17
Per cent	100	4.4	18.9	68.4	8.3

pupated near the soil surface at a depth of about 1 cm., while they tended to go slightly deeper in moist soil. Pupal chambers were found at a mean depth of 1.1 cm., 1.8, 2.1 and 2.0 cm. in the air dried soil and in the soils with 10, 20 and 30% moisture contents respectively. These results are in accord with the findings of WIESMANN (1952).

Pupal chambers of the cotton leaf worm were generally set at sharp angles in the soil irrespective of its moisture content. In air dried soil, they were found at a mean angle of 49°, but in soil with 10% moisture content they were at 67°. In soil with either 20 or 30% moisture contents, pupal chambers were situated at an angle of about 71° (Table II).

TABLE II

Effect of soil moisture on position of pupating larvae of Prodenia litura in soil, in laboratory (Mean temp. 29°C.)

Percentage soil moisture content	Number of larvae used	Position of pupating larvae in soil/angle		
		Max.	Min.	Mean \pm S.E.
Air dried	50	147	6	49 \pm 1
10	50	109	45	67 \pm 4
20	50	136	30	71 \pm 3
30	50	124	32	71 \pm 2

(C) RATE OF DEVELOPMENT OF PUPAL STAGE. — Duration of the pupal stage was reported by many workers without any reference to the state of soil moisture. BISHARA (1934) gave an average of 8 days for pupal duration during summer and 2 months during winter. WILLCOCKS and BAHGAT (1937) reported that 10 to 14 days were nearer to an average of pupal duration in summer and from about 30 to 69 days during winter. WIESMANN (1952) stated that from pupae of same age males always emerged 1 to 2 days before females. However, JARCZYK et al (1957) informed that the pupal duration was mainly influenced by temperature and relative humidity. He found that the pupal stage at a temperature of 25-26°C., lasted 7.5 and 9 days for the females and males, respectively, while at 28-29°C. it lasted 7.5 days for males and 6.5 days for the females.

Development of pupae of *Prodenia litura* is considerably affected by the moisture contents of the soil. Excessive moisture in the soil apparently prolonged the duration of the pupal stage. Treatments of soil with decreasing moisture showed that the shortest duration was obtained for pupae in air dried soil (9.8 days for males and 9.0 days for females). The mean pupal durations obtained in soils of 10, 20 and 30% moisture contents were 9.8, 10.1 and 11.1 days for males and 8.7, 9.1 and 9.5 days for females, respectively (Table III).

TABLE III

*Effect of decreasing soil moisture on development
of male and female pupae of Prodenia litura, in laboratory
(Mean temp. 29°C.)*

Soil moisture content	Number of pupae used	Number of moth emerged	Duration of pupal stage in days		
			Max.	Min.	Mean \pm S.E.
Air dried	40	13 males	11	9	9.8 \pm 0.2
		20 females	11	8	9.0 \pm 0.3
10%	40	17 males	11	7	9.8 \pm 0.3
		18 females	10	8	8.7 \pm 0.2
20%	40	19 males	12	9	10.1 \pm 0.1
		21 females	11	8	9.1 \pm 0.2
30%	40	17 males	12	10	11.1 \pm 0.2
		20 females	11	8	9.5 \pm 0.52

Similar results were obtained from a set of treatment in which the moisture was maintained constant throughout the experiment (Table IV). It was noticed that durations of female pupae were shorter than those of male pupae irrespective of the moisture content of the soil. Analysis of variance showed that the differences

between means of pupal durations due to soil moisture were highly significant in all treatments except in the case of the female pupae in soil with decreasing moisture.

TABLE IV

*Effect of constant soil moisture on development
of male and female pupae of Prodenia litura, in laboratory
(Mean temp. 29°C.)*

Soil moisture content	Number of pupae used	Number of moth emerged	Duration of pupal stage in days		
			Max.	Min.	Mean \pm S.E.
Air dried	40	13 males	11	9	9.8 \pm 0.2
		20 females	11	8	9.0 \pm 0.3
10%	39	17 males	14	9	11.2 \pm 0.3
		15 females	12	8	9.7 \pm 0.2
20%	37	16 males	10	9	9.9 \pm 0.1
		17 females	9	8	8.7 \pm 0.1
30%	37	16 males	11	10	10.4 \pm 0.1
		12 females	11	9	9.3 \pm 0.2

(D) RATE OF EMERGENCE OF MOTHS. — Emergence of moths is greatly affected by the moisture content of the soil. Excessive dry clay soil was reported by BISHARA (1934) to mechanically hinder the emergence of the moths. Results showed that the highest rates of emergence of moths (95 and 93%) were obtained from soils with

TABLE V

*Rate of moth emergence of Prodenia litura in relation
to constant soil moisture, in laboratory
(Mean temp. 29°C., R.H. 61%)*

Soil moisture content	Number of pupae used	Number of moths emerged	Rate of emergence per cent
Air dried	30	13	43
10%	30	28	93
20%	20	19	95
30%	25	17	68

20 and 10% moisture contents. Dry soil was found to be the least favourable for moth emergence as only 43% of the moths succeeded to emerge. Soil with high water content (30%) allowed about 68% of the moths to emerge (Table V).

SUMMARY

Investigations were conducted in the laboratory to explain the relation of soil moisture to pupation and emergence of moths of the cotton leaf worm. Observations showed that full grown larvae were less inclined to pupate in dry soil or in soil with excessive moisture. Soil with 20% moisture content was the most favourable for pupation.

Soil moisture delimits the depth at which the larvae pupate. In dry conditions larvae pupated near the soil surface. Pupal chambers were set at sharp angles in the soil irrespective of its moisture content.

Subsequent effects induced by soil moisture on pupal development showed that excessive soil moisture prolonged the pupal duration while the shortest pupal period was obtained in dry soil. The latter was the least favourable for moth emergence while soil with 20% moisture content was the most favourable.

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FACTORS AFFECTING LONGEVITY AND REPRODUCTIVE POTENTIALS OF MOTHS OF THE COTTON LEAF WORM, *PRODENIA LITURA*

[*Lepidoptera: Noctuidae*]

(with 3 Text-Figures)

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INTRODUCTION

Little has been reported in the literature on the factors affecting the size of population of the cotton leaf worm, *Prodenia litura*. Knowledge of such factors, whether biological or ecological, will help in understanding the general trend of population of this pest in the field.

Field and laboratory investigations were made to study the seasonal variation in the longevity of the moth as well as the effect of food and mating on its survival and reproductive capacity. These experiments were carried out in the Cotton Insects Investigations Section of the Ministry of Agriculture in Giza, during the year 1958.

MATERIALS AND METHODS

Longevity of the cotton leaf worm was determined in different seasons in the field. For this purpose twenty pairs of recently emerged moths were used in every season. Each pair was confined in a separate cage and provided with 20 % sugar solution as a source of food. All cages were put in a shaded place outdoors. Records

of temperature and relative humidity of the atmosphere in the vicinity of the cages were obtained from the Weather Bureau, at Giza.

Effect of mating on the longevity of moths was tested in the laboratory. Paired moths as well as single males and females were confined in separate glass jars opened at both ends. In each case, twenty replicates were used. Jars were set on petri-dishes and were covered at the top with cheese cloth secured with rubber bands. Each pair of moth was provided daily with water instead of sugar solution. Hatching of eggs of tested females was considered as an indication of mating. A record was kept for the life span of each moth. Other experiments were made on the effect of food on the longevity of moths as well as on the rate of oviposition and hatchability of eggs. Newly emerged moths were divided into four groups of 15 pairs each. Three groups were offered 20% honey solution, 20% sucrose and water respectively while the fourth group remained unfed. Each pair was caged in a glass jar similar to those described above. Small branches of *Nerium oleander* were placed into the cages to provide suitable sites for oviposition. Food was provided twice a day, at 9 a.m. and 6 p.m. Egg-masses were collected daily, counted and kept in vials until they hatched at room temperature.

RESULTS AND DISCUSSION

Longevity of moths is considerably affected by climatic conditions prevalent in the different seasons. In general, moths lived longer in winter and early spring

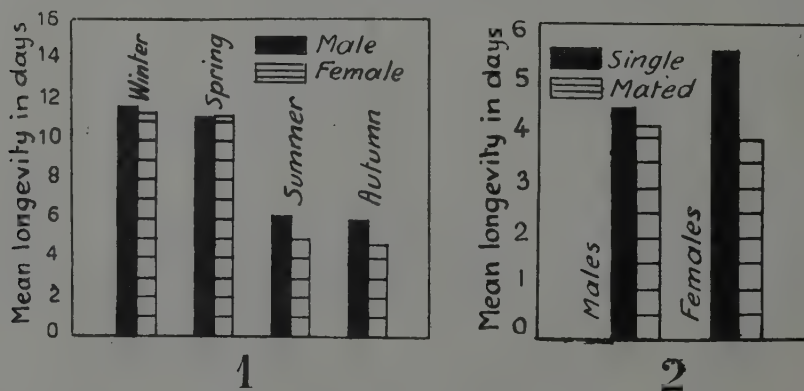


FIG. 1: Seasonal variation in longevity of moths in the field. — FIG. 2: Effect of mating on longevity of moths in the laboratory.

than in summer or autumn. The mean longevity of adults in these seasons were 11.7, 11.2, 6.2 and 5.9 days for males and 11.4, 11.3, 5 and 4.7 days for females respectively

(Fig. 1). Cold weather prolonged longevity of the moths, while warm weather shortened it. The mean temperatures recorded during the experiment were 13.3, 15.2, 27.0 and 25.4° C. in winter, spring, summer and autumn in the same order mentioned. Records of longevity also showed that males generally outlived females. Analysis of variance confirmed that the differences in the mean longevity of both male and female moths, obtained in the different seasons, were highly significant.

Mating has affected greatly the longevity of female moths. Unmated females had a mean longevity of 5.7 days compared with 3.9 days obtained for mated ones, (Fig. 2). This difference was found to be highly significant. No significant difference was found between mean longevity of unmated and mated males as the mean durations were 4.6 and 4.2 days, respectively.

Food as a factor affecting longevity, rate of oviposition and hatchability of eggs was reported by many workers. According to NORRIS (1936), some *Rhopalocera* require both sugar and water for normal longevity and reproduction. WILLCOCKS and BAGHAT (1937) mentioned that moths of *Prodenia litura*, when fed on honey diluted with water laid more eggs than if left unfed. WIGGLESWORTH (1953) found that *Agrotis segetum* deposited fertile eggs when fed on 20-40% solution of glucose, while it laid 40-50% infertile eggs if given 5% glucose. Also corn earworm imagoes fed on solutions of inverted sugar and glucose lived longer than imagoes not fed or given only water (CALLAHAN, 1955).

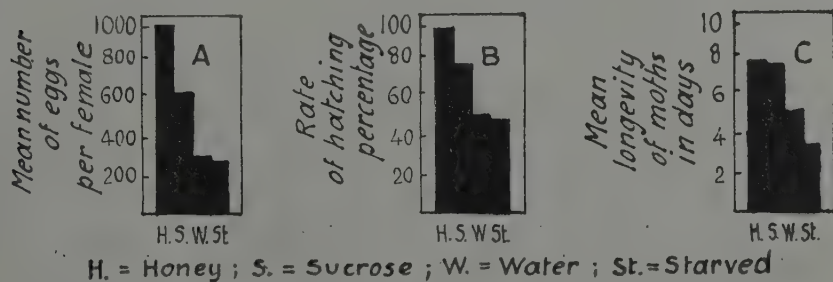


FIG. 3: Effect of food on longevity of moths, rate of oviposition and hatchability of eggs.

Longevity of moths is considerably influenced by the type of food offered. Moths had the longest life span when fed on solution of 20% honey or sucrose while the shortest period was obtained for the unfed ones. Mean longevity obtained were 8.2, 8.1, 5.5 and 3.6 days for moths fed on solutions of honey, sucrose, water and unfed moths respectively (Fig. 3, C). Statistical analysis showed significant differences between longevity obtained in all treatments.

The reproductive capacity of the moth is also affected by the type of food offered. Results showed that moths when fed on honey solution laid the highest record of eggs while the lowest was laid by unfed moths (Fig. 3, A). The mean

number of eggs laid per female was 1007, 629, 304 and 270 for moths fed on solutions of honey, sucrose, water and unfed moths respectively. Variations in number of eggs obtained in the different treatments were found to be significant.

A positive relationship also exists between the type of food and hatchability of eggs. It was found that rates of hatching were 98, 83.3, 54.4 and 53.6 % for eggs deposited by females fed on solutions of honey, sucrose, water and unfed moths respectively (Fig. 3, B).

SUMMARY

Longevity of moths of *Prodenia litura* was determined under natural conditions in different seasons. Laboratory investigations were made on the effect of mating and type of food on survival of moths. In addition, the effect of food on rate of oviposition and hatchability of eggs was tested.

Cold weather was found to prolong the longevity of adults as moths lived longer in winter and early spring than in summer or autumn. Mating shortened longevity of females while it had no significant effect on the males. Longevity of moths was also prolonged when fed on twenty per cent solutions of honey or sucrose, while unfed moths had the shortest life span.

Rate of oviposition and hatchability of eggs were significantly dependent on the type of food offered to the moths.

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PHYLLOCNISTIS CITRELLA STANTON, A MAIN CITRUS PEST IN SAUDI ARABIA

[*Microlepidoptera: Lyonetiidae*]

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Citrus cultivation has developed considerably in Saudi Arabia in recent years. Success of its expansion appears, however, to be hindered by its continuous attack by over twenty different insects and diseases among which the citrus leaf miner, *Phyllocnistis citrella* Stainton, is believed to be the most serious.

23, 1962 This leaf miner is known to occur in eastern and southern Asia, South Africa, Australia and the Philippines. Its description and information on its life cycle were given by FLETCHER (1920), CLAUSEN (1931), VOUTÉ (1934), SHIRAKI (1934) et al and are summarized as follows:

Under summer conditions in Japan, a generation of this minute moth may be produced in six weeks, so the potential rate of increase is very great. Most of the injury, however, is inflicted by the first two spring generations. It passes the winter solely in the adult stage, a habit uniform in the genus. Six generations are produced each year in southern Japan. The egg, larval, and pupal periods cover 9.20 and 9 days, respectively. The egg, which is 0.27 mm. in length, flat and without sculpturing or covering, is laid near the midrib. The young larva enters the leaf immediately upon hatching and begins the formation of the characteristic serpentine mine. This is always continuous, and the larva never leaves the mine to form another. Feeding is restricted to the sap derived from the epidermal and adjacent layers of cells and the glistening, transparent covering which remains clearly reveals the larva feeding beneath. The larval stages are similar in form, though the head and thoracic segments of the earlier stages are proportionately larger. The mature feeding larva, by a regular contraction and expansion of the body, is capable of movement within the mine only backwards and forwards, and when removed from the mine it is unable to accomplish any ordered locomotion. The pupation cell is usually placed at the margin of the leaf, the edge being drawn over so that three sides are formed of fresh leaf tissue and the fourth by the thin layer of dermal tissue and the whole lined with a delicate layer of silk.

Emergence takes place largely during the early morning hours. The adults are nocturnal in habit, never seen in the field. After six days the females begin oviposition upon the young foliage.

Distribution in relation to faunal districts and areas

Saudi Arabia, from a geographical standpoint, lies in the temperate and tropical zones. Some areas reach an elevation of about nine thousand feet above sea level. However, four climatological zones may be defined as follows:

(1) Coastal regions on the Red Sea and the Persian Gulf; characterized by a warm winter and a hot humid summer with temperature exceeding 100°F. and the relative humidity over 85%.

(2) Desert region covering most of the central area of the country where the highest elevation does not reach over 3000 feet; characterized by a cold winter sometimes with freezing temperatures and a dry hot summer with temperature reaching 115°F. and relative humidity as low as 10%.

(3) Northern region; an elevated plateau with climate similar to that of Mediterranean region; and

(4) Highland region exceeding 5000 feet above sea level; characterized by a fairly moderate summer, a cold winter and relatively low humidity throughout the year.

Citrus cultivation extends over most of these regions despite the fact that citrus trees suffer from frost in the highland area. No records of infestation by this leaf miner were reported to become established in either northern or highland regions, even in case of infested seedlings transferred to those regions. Also low temperature and hot climate prevailing in those regions did not help this miner to develop or succeed as a pest. The author found during June 1956, that all larvae and 63% of the pupae were dead when the temperature reached 115°F. immediately following hot winds.

Moisture seemed to have no apparent effect on the distribution of this pest as it was found in both coastal and desert regions where the relative humidity of the atmosphere ranged between 100 and 10 %, respectively. However, an outbreak of *Phyllocnistis* was observed during the last part of May 1957, in Riyadh, sequent to a heavy rainfall which induced emergence of moths from the pupae. At that time all the newly formed leaves were found to be infested.

CLAUSEN (1931) reported that in hot humid regions in Japan, all mines formed by *Phyllocnistis* were found on the upper surfaces of the leaves. However, observations made by the author in Saudi Arabia showed that these mines were almost equally present on both surfaces of the leaves in dry and humid regions as well.

Type of injury

When a larva mines in the leaf tissue, it feeds on the leaf contents thus damaging most of the leaf. In incidence of heavy infestations leaves become malformed

and curl before they fall off the tree. Consequently, loss of three leaves will result in the disturbance of physiological processes of same tree. In Asiatic countries, however, it was reported that such infested trees are subjected to a secondary infection by the cancer citrus disease. The latter is not prevalent in Saudi Arabia until the present time.

Host plants

Major host plants include different varieties of citrus trees which vary in their susceptibility to attack. They are arranged in a descending order according to degree of damage as follows:

Citrus medica, *C. myrtifolia*, *C. aurantium*, *C. aurantium* var. *deliciosa*, *C. limonum* var. *pusilla* and *Fortunella marginata*.

Jasminum sambac was the only ornamental plant infested by *Phyllocnistis*.

Control methods

Behaviour of this leaf miner as well as the state of the tree present considerable difficulty when one prepares to combat this pest. Such difficulties include (1) its inaccessibility due to its mining habits and (2) the successive new growths, sites of oviposition, which are sensitive to many insecticides.

Timing of application of insecticides was based on biological information obtained from a study conducted on this pest in the nursery of the horticulture department. As spring and fall generations of this leaf miner are the most dangerous, its control should be limited to and during these two seasons.

Shortly before the discovery of chlorinated hydrocarbons and organic phosphorous compounds, control measures used in Asiatic countries against this pest included: (1) mechanical rubbing of injured leaves to kill larvae in mines, (2) use of 0.3 % nicotine sulphate spray separately or mixed with emulsified oils, (3) fumi-

TABLE I

Comparative effectiveness of several insecticides against fall generation of Phyllocnistis citrella in Riyadh, Saudi Arabia, 1958.

Insecticide	Percentage rate of mortality of larvae after different periods			
	10 days	20 days	30 days	40 days
Parathion 0.03%	95	55	18	20
DDT 0.5%	83	86	23	15
Gamma Isomer 0.65%	83	31	20	20
Dieldrin 0.07%	90	78	20	14
Nicotine sulphate 0.3%	72	26	23	10
Control	30	20	17	11

gation of trees by hydrocyanic gas and (4) insertion of 1/2 gram of potassium cyanide crystals into a small hole in the 3-8 feet high three stem to kill 65-95 % of larvae.

Although no effective methods for combating this pest have been developed, the author made an attempt to use several insecticides with different concentration against it (Tables I and II). These insecticides were Parathion, DDT, Dieldrin, Nicotine sulphate, Malathion, Heptachlor and Gamma Isomer.

This experiment showed that Parathion, DDT, Gamma Isomer and Dieldrin gave similar results after 10 days from treatment (Table I). However, no residual effect was found after one month. Also no harmful effect appeared on the leaves or fruits.

TABLE II

Comparative effectiveness of several insecticides against spring generation of P. citrella, in Riad, Saudi Arabia, 1959.

Insecticide	Percentage rate of mortality of larvae after different periods			
	1 week	2 weeks	3 weeks	4 weeks
Parathion 0.03 %	100	22	15	10
Malathion 0.015 %	100	15	10	12
Heptachlor 0.5 %	95	20	12	15
Dieldrin 0.07 %	97	48	17	10
D.D.T. 0.5 %	90	52	15	11
Gamma Isomer 0.5 %	100	36	10	8
Nicotine sulphate 0.3 %	50	10	10	14
Control	15	12	10	10

Table II showed that nicotine sulphate was ineffective. However, phosphorous compounds as Malathion and Parathion as well as chlorinated hydrocarbons such as DDT, Gamma Isomer, Heptachlor and Dieldrin gave satisfactory results against this pest but after 2-3 weeks reoccurrence of heavy infestation took place.

Therefore, in order to control this pest satisfactorily, it was found necessary to apply three treatments every ten days in the spring and twice during the fall at 14 days interval.

Parasites

In Ceylon, natural enemies play an important role in suppressing large populations of this pest. Parasites belonging to the genera *Aginiaspis* and *Eurytoma* were reported to kill about 80 % of the larvae and pupae in that country. Another parasite of the super-family Chalcidoidea was found to cause mortality to 60 % of the larvae and pupae in Japan. However, no records were obtained from Saudi Arabia for parasitic species attacking this leaf miner.

Acknowledgments

The author wishes to express his gratitude to Messrs. ABDULLAH EL-DABBAGH, Director General of Ministry of Agriculture in Saudi Arabia, for his keen interest in this study and encouragement; MIRZA, specialist in the Crop Protection Department for his technical assistance; M. S. EL-ZOHEIRY for reading the manuscript and A. ALFIERI for verifying the identity of this species and for providing the author with useful references.

CHEMICAL CONTROL OF SOME COTTON INSECTS UNDER FIELD CONDITIONS, IN EGYPT

(with 9 Tables)

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C O N T E N T S

Introduction. — Literature review. — Materials and methods. — Experimental results (on the cotton leafworm, cotton boll worms, and cotton leafhoppers). — Discussion and conclusions. — Summary. — Literature cited.

I N T R O D U C T I O N

Just recently it was realized that chemicals have to be applied on a wide scale for combating the cotton leafworm in Egypt if a successful control of this insect is sought. The unsatisfactory results obtained on applying other measures including mechanical, agricultural and biological control methods called for such a decision.

In spite of being a chewing insect, feeding on the cotton leaves and other plant parts the worm is subjected to the contact effect of any material that might cover such attacked parts.

The use of newer insecticides, which proved efficient in the control of similar pests abroad, is still limited under the present conditions prevailing in Egypt due to their high toxic nature. However, the application of such effective insecticides should be extensively practiced in order to be able to solve the cotton insects problem in our country.

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In the present study, which was carried out during 1954 at the Faculty of Agriculture Farm of Alexandria University at Sabahieh, a comparison of the effect of some of these and other materials on some cotton insects was carried out under field conditions in order to analyse their insecticidal qualities.

The experiment was originally planned to detect the action of the applied chemicals on the cotton leafworm, *Prodenia litura* F. However, the picture concerning their effect on the cotton bollworms (both the spiny bollworm, *Earias insulana* and the pink bollworm, *Pectinophora gossypiella*) as well as on the cotton leafhopper, *Empoasca decedens* Paoli (identified by Dr. DAVID A. YOUNK of the U.S. Department of Agriculture, through the courtesy of Miss SOPHY PARFIN, entomologist, Smithsonian Institute U.S. National Museum, Washington) was also analysed.

LITERATURE REVIEW

Among the insecticides recommended for the control of the cotton pest locally and abroad the following are the most prominent:

Insect pests	Chemicals used for control	References
American cotton leafworm, <i>Alabama argillacea</i>	Arsenicals, Toxaphene, Cotton-dust (3/10/40).	U.S. Dept. Agr. (1949) and later publications.
Cotton leafworm, <i>P. litura</i>	DDT and B.H.C.	Cannon et al. (1946).
Various cotton insects.....	DDT, Aldrin, Dieldrin, Toxaphene, B.H.C. and Parathion.	Farrar (1952), 5th Annual Cotton insects Conference.
Cotton leafworms.....	Chlordane and Parathion.	Ivy and Scoles (1952).
Cotton leafworms in Egypt	Cotton-dust, Toxaphene, Parathion, DDT and Calcium arsenate.	Weisman (1952).

Several other publications dealing with the control of cotton insects under field conditions have appeared comparatively recently but almost all of them point out the efficiency of the same chemicals listed above.

MATERIALS AND METHODS

The chemical substances used during this investigation are:

(1) Salitol, a stomach poison consisting of calcium arsenate and lime sulphur at the following ratios: 33.3% calcium arsenate, 33.3% sulphur and 33.3% calcium hydroxide.

(2) Parathion, a newer phosphorous insecticide which is an ester of thio-phosphorous acid, applied as 1% wettable dust prepared from a 25% wettable Parathion product known as "Thiophos" (produced by the AMERICAN CYANAMID CO.), at the rate of about 12 kilos per feddan. This product was offered to the authors free of charge for experimental purposes by the Company Agent in Egypt.

(3) Agrocide cotton dust (3/10/40) having the composition 3% gamma isomer B.H.C., 10% DDT, 40% sulphur and 47% inert ingredients.

(4) Toxaphene, a chlorinated hydrocarbon which is one of the promising insecticides of its group used as a 2% spray (water emulsion) prepared at present from an original 50% preparation supplied by the SHELL CO. and applied at the rate of about 200 litres (4 litres of the active ingredient) per feddan.

(5) Chlordane, another chlorinated hydrocarbon preparation used as 2% dust prepared from an original liquid form. The heavy liquid is dissolved in chloroform and thoroughly mixed with the corresponding amount of inert ingredient (which was soil rock phosphate in this case). Upon evaporation of the chloroform the chlordane preparation is obtained at the required concentration. This material was applied at the rate of about 8 kilos per feddan.

These five insecticides were applied in the experimental cotton field which was divided into sixty small plots of about 2×2 kassabahs (about 56 sq. metres) each. Every treatment was replicated ten times so that each material was applied to ten of the plots distributed at random. Ten randomised plots distributed among the treated ones were left untreated as a check. The distribution system of the experimental plots is outlined hereunder.

				North							
	6	1	6	2	4	5	2	3	4	3	
	5	2	3	5	1	6	4	5	1	6	
West	4	6	4	6	3	3	5	2	3	2	East
	1	3	2	1	5	2	1	1	6	5	
	3	4	5	3	6	4	3	6	5	4	
	2	5	1	4	2	1	6	4	2	1	
					South						

In addition to the ten plots left as a check without treatment among the treated plots, ten other plots aside from these were considered as a confirmatory check. This was done to avoid any confusing or unreliable picture that might be caused to the check plots through drifting of insecticides during spraying or dusting of neighbouring plots or at least through the fumigant action of chemicals applied nearby. The plots receiving a certain treatment were marked with long wooden sticks coloured with an indicative colour to facilitate the work for ordinary labourers.

Techniques concerning the cotton leafworm

Artificial inoculation with cotton leafworm egg masses was practiced during this investigation. Before starting the experiment egg masses present in the field were picked by hand. In each plot a certain number of egg masses (usually amounting to approximately the same number of eggs) was pinned to the underside of leaves of some cotton plants distributed at random within the plot, just before the insecticide application. The dates of inoculation, the number of eggs per plot and the time of treatment are indicated in Table I.

TABLE I

Types and dates of treatments during the present experiment.

Treatment	Date during 1954	Type (method of application)	Remarks
1	June 16th.	From down upwards	1st. inoculation date
2	July 6th.	From down upwards	2nd inoculation date
3	July 18th.	From down upwards	} New egg masses were picked up regularly.
4	August 3rd.	From down upwards	
5	August 17th.	From up downwards	
6	August 29th.	From up downwards	

Dusts were applied by knap-sac dusters early in the morning when dew is still covering the plants. In cases where dusting was carried out late during the day artificial dew was produced by spraying plants with water ahead of dusting. Spraying was carried on by knap sac sprayers or small power sprayers of about 60 pounds capacity exerting a pressure of about 50 lbs. to the square inch. Egg masses naturally deposited after the insecticide application were also hand picked. Observations on introduced masses concerning the hatching and the susceptibility of the hatch and the developing larvae to the insecticides, as well as the amount of worm damage to foliage were made throughout the experiment.

Techniques concerning the cotton bollworms

Samples from various replicas were examined to detect the extent of infestation with both the pink and the spiny bollworms. Counts on samples representing the bolls which succeeded to open as well as those which failed to open were examined before and after the various treatments.

Techniques concerning the cotton leafhopper

The hoppers population in each of the plots was examined by sampling before and after the insecticide applications. The number of hoppers caught in a collecting net (40 cms. diameter and stick 1 metre long) by ten sweeps within each

plot at a time is considered indicative of the population. The number of hoppers from the ten replicas receiving the same treatment is compared with those from plots treated with other materials. Results were statistically analysed to detect their significance.

EXPERIMENTAL RESULTS

On the cotton leafworm

Results on the effect of insecticides in the control of the cotton leafworm are summarized in Table II.

TABLE II

Comparative effect of insecticides used.

Chemicals applied	Ovicidal effect of insecticides based on 10 egg-masses			Vegetative (foliage) destruction	Weight of yield in pounds per 10 treated plots
	Hatched egg-masses	Unhatched egg-masses	Worms hatched indicating worm abundance		
Salitol	0	1	Few died	Very much	177.75
Parathion	8	2	Some died	Medium	203.25
Cotton-dust	8	2	Few died	Little	223.75
Toxaphene	7	3	Some died	Medium	245.00
Chlordane	7	3	Few died	Much	197.50
Check (among treated)	9	1	Few died	Much	181.75
Check II.	10	—	Few died	Much	165.00

From the data outlined in Table II, the following deductions can be made:

(1) Toxaphene is superior to the other chemicals used during the present study under the prevailing conditions. The increase in the yield of toxaphene treated plots over that of the check and of those receiving other treatments is obvious.

(2) Plots treated with cotton dust showed the minimum vegetative destruction. This might be attributed to the fact that DDT enhances the vegetative growth and thus helps to conceal the damage to a certain extent.

(3) Salitol is the least efficient of the materials used here. It gives no appreciable control and saves very little if any of the crop.

(4) Control plots distributed among the treated plots appear to be affected, although to a slight degree, by the insecticides drifting during application to neighbouring plots or from the fumigant action of some of these materials. This appears from the fact that the yield of such check plots is better than of the control plots chosen away from the treated ones (aside from these).

Detailed data concerning the yield in the various experimental plots is given in Table III.

TABLE III

Detailed data of the yield from the different experimental plots (replicas).

Chemicals applied	Weight of yield in pounds in the different small plots										Total
Salitol	18.25	20.75	17.50	17.25	17.75	19.75	16.50	13.75	17.75	18.50	177.75
Parathion	21.00	14.75	17.50	23.75	23.00	20.75	23.50	19.50	21.75	17.75	203.25
Cotton-dust ...	18.75	20.75	14.50	16.25	27.00	27.50	22.00	29.50	23.75	23.75	223.75
Toxaphene	21.75	22.75	23.25	35.50	23.25	21.50	22.00	25.25	24.00	23.75	245.00
Chlordane	21.75	19.25	18.25	17.75	21.25	17.25	23.25	19.75	20.25	18.75	197.50
Check	19.50	20.00	24.25	16.25	20.50	15.00	18.50	18.50	17.25	12.00	181.75

The statistical analysis of the above data is outlined in Table IV.

TABLE IV

Analysis of variance for the yield obtained from plots receiving different insecticide treatments.

Source of variance	D.F.	S.S.	M.S.	F.
Materials	5	313.65	62.73	6.17
Dates	9	48.31	5.37	0.5
Correction factor	1	25092.15	—	—
Total	59	907.26	—	—
Error (residue)	45	545.31	12.12	—

L.S.D. = 3.1

From a consideration of the means in view of the L.D.S. it appears that some of the used chemicals significantly affect the yield in comparison to the check.

The arrangement of the means of yields according to magnitude shows this relationship clearly. The various means are: Toxaphene 24.3, Cotton-dust 22.3, Parathion 20.3, Chlordane 19.7, Check 18.8, Salitol 17.8.

Both Toxaphene and Cotton-dust cause a significant increase in the yield over the control (check). The yield from toxaphene treated plots is significantly higher than that from parathion, chlordane, check and salitol. That from cotton dust plots is significantly higher than that from the check and salitol. Yield from parathion treated plots is significantly higher than that from the check and salitol. Yield from parathion treated plots is significantly higher than that from salitol. No significant variation is noticed between yields when other comparisons between materials are made.

On the Cotton bollworms

Readings on the effect of the used materials on the degree of infestation with both the pink bollworm, (*Pectinophora gossypiella*) and the spiny bollworm (*Earias insulana*), are summarized in Table V.

TABLE V

Effect of insecticides on the degree of infestation of cotton with the bollworms.

Treatment	Total number of worms per 100 bolls (10 samples)						Number of bolls open per 1000 (escaped infestation)	Yield in pounds
	1		2		3			
	Pink	Spiny	Pink	Spiny	Pink	Spiny		
Salitol	15	0	17	9	26	32	552	177.75
Parathion	14	0	10	10	22	35	578	203.25
Cotton-dust	12	1	15	7	26	32	597	223.75
Toxaphene	15	0	18	8	23	34	468	243.00
Chlordane	14	0	15	10	23	38	580	197.50
Check (among treated) .	18	2	21	13	29	39	570	181.75
Check (away)	18	8	22	13	31	42	565	165.000

1 = readings on August 2nd, after third treatment and one day before fourth treatment.

2 = readings on August 17th, after fourth treatment and just before fifth treatment.

3 = readings on August 29th, after fifth treatment and just before sixth treatment.

From Table V it appears that:

(1) The degree of infestation with both bollworms increases as the season proceeds in case of both treated and untreated plots. This indicates the production of several generations of these insects during the same season.

(2) Infestation with the pink bollworm starts earlier in the season than that of the spiny worm.

(3) The chemicals applied here helped slightly in controlling both bollworms, but none gave quite satisfactory results under the prevailing conditions.

The failure of such materials in bringing a significant control picture might be attributed to any of the following causes:

(a) The non-specificity of the insecticides used for these particular pests.

(b) The concentrations applied might not be sufficient for causing appreciable control.

(c) The unsuitability of the method of application for the purpose, in view to the particular breeding habits of both worms.

Modifications in one or more of these factors might lead to a better control picture of such worms, a procedure planned for future work.

There is little variation in the numbers of bolls that succeeded to open (which escaped infestation) among treated plots. Meanwhile these are not much different from those in the untreated plots. The variation in yield noticed here is thus dependent on the extent of infestation with the cotton bollworms affecting the quality of the bolls as well as the amount of fibres and seeds produced therein.

Statistical analysis of the data concerning the bollworms is outlined in Tables VI and VII.

TABLE VI

Analysis of variance for results concerning effect of chemicals on the pink bollworm.

Source of variance	D.F.	S.S.	M.S.	F.
Correction factor	1	6160.5	—	—
Total corrected	17	488.5	—	—
Dates corrected	2	366.5	183	61.0
Materials corrected	5	90.5	18	6.0
Error (residue)	10	31.5	3	—

$$\text{L.S.D.} = \sqrt{2} \cdot t_{10; 70.5} \cdot \frac{\sqrt{\frac{31.5}{10}}}{\sqrt{3}} = 1.414 \times 2.23 \times 1 = 3$$

TABLE VII

Analysis of variance for the spiny bollworm results.

Source of variance	D.F.	S.S.	M.S.	F.
Correction factor	1	4050	—	—
Total corrected	17	3912	—	—
Dates corrected	2	3843	1921	960
Materials corrected	5	47	9.5	4.3
Error	10	22	2.2	—

L.S.D. between 2 means of materials = 2.65

Referring the differences between means to the L.S.D. it appears that in case of pink worm: (1) The check is significantly different from each of the applied materials; (2) Parathion is significantly different from both Toxaphene and Salitol.

In case of the spiny bollworm: (1) The check is significantly different from Parathion, Toxaphene, Salitol and Cotton-dust; (2) Chlordane is significantly different in action from the Cotton-dust.

On the leafhoppers

The changes encountered in the leafhopper population during the season as affected by the various treatments are indicated by the samples represented by the number of insects caught in ten sweeps. The number of insects in samples of each ten plots receiving the same treatment are added together. Both adult leafhoppers and nymphs are taken into consideration. The figures are included in Table VIII.

TABLE VIII

Effect of insecticides on leafhopper population.

Treatment	After first treatment of June 16th.		After second treatment of July 6th.		After third treatment of July 17th.		After fifth treatment of August 17th.	
	June 22nd.	July 3rd.	July 11th.	July 14th.	July 17th.	July 25th.	August 1st.	August 24th.
Salitol	101	76	101	34	49	135	159	22
Parathion	100	88	86	39	57	147	152	25
Cotton-dust	119	85	56	6	65	170	155	24
Toxaphene	95	99	73	0	79	175	179	27
Chlordane	129	113	52	87	52	166	314	33
Check I	185	133	85	59	45	195	197	55
Check II	230	150	150	157	—	247	235	—

From Table VIII the following points are deducted:

(1) The hopper population is considerably reduced on insecticide application. The reduction extent varies in case of the different materials with toxaphene seeming to be the best. The figures one week after first treatment (on June 22th) show that while the counts of the samples of check I and II are 185 and 230, respectively. It is only 95 insects in case of the sample of Toxaphene treated plots. Numbers in case of other treatments range between 100 (for Parathion) and 129 (for Chlordane). Salitol, although a stomach poison, brought a comparatively good control picture (101 insects per sample) on this piercing sucking insects. This can be attributed to the effect of sulphur entering in its composition.

Counts made 3 weeks after the first application (July 3rd) still show the value of these insecticides in controlling this pest. Similarly, readings after second and third treatments as well as those after the fifth confirm such view.

(2) At times of first and third treatments there seems to be peaks of generations of this insect. Treatments have thus to be so timed to hit the insect at such periods.

(3) None of the used materials seems to have a residual effect since none of them prevented the normal build up of population following applications.

(4) The control picture brought about by each insecticide is not stable due to the very agile nature of this insect and its local migrations.

(5) Most probably some, at least, of the used insecticides have a fumigant action since the check plots distributed among the treated ones show a lesser leaf-hopper population than those away from the treated area.

Analysis of variance of the data outlined is given in Table IX.

TABLE IX

Analysis of variance of data on leafhopper control by insecticides

Source of variance	D.F.	S.S.	M.S.	F.
Correction factor	1	423282	—	—
Total corrected	47	137751	—	—
Dates corrected	7	116965.5	16709	42
Materials corrected	—	6922	1384	3.5
Error	35	13863.5	396	—

L.S.D. between 2 means of materials=20.

Referring the differences between means of materials to this L.S.D. value, it appears that no significant difference occurs except between the check and the whole group of materials. The means arranged according to magnitude for check, Chlordane, Toxaphene, Parathion, Cotton-dust and Salitol are: 119.2, 96.9, 90.9, 86.8, 85.0, and 84.6, respectively.

DISCUSSION AND CONCLUSIONS

The fear of destruction of useful insects by chemicals should not prevent their use in cases where such materials are effective against a serious pest. Beneficial insects could be bred in captivity (artificially) and then released at periods where chemicals are not in use.

In applying chemicals for insect control many factors have to be taken into consideration in order to get most of the benefit sought. It should be always remembered that the efficiency of a chemical in controlling an insect depends on various factors most prominent among which are: (a) its nature determining the method and rate of action, (b) concentration and method of application, (c) time of application, (d) ability to stand environmental conditions, (e) biology and biotic potential of the concerned insect.

On studying the effect of an insecticide for the control of a certain pest, under field conditions, all prevailing conditions including the status of other insects, should be thoroughly investigated in advance.

Judging from the results of the present experiment it is found advisable to use 20% Toxaphene at the rate of 200 litres (4 litres of active ingredient) per feddan at about 2 weeks intervals throughout the season of infestation. Treatments should be started as early as possible, just on the onset of attack and continue further or till the close up of the infestation period.

Other than the cotton leafworm this insecticide helps to control both the bollworms and the leafhoppers and probably other pests as well.

Although the populations of the parasites and predators of cotton insects have not been studied during this experiment, yet these have been abundantly present throughout the season without being strikingly affected. This observation stands in favor of the use of chemicals for the control of the cotton insect pests without risking the loss of insects effective in biological control.

The procedure of artificial inoculation with the cotton leafworm egg masses followed here, although tedious yet helps to eliminate (minimise) several variable factors that might alter the reached picture. Such technique helps to estimate the amount of damage caused by this worm at various infestation intensities. Although each of the plots received only 10 egg masses (about 3000 eggs) throughout the season (which is comparatively a very light degree of infestation in consideration of natural infestation) yet the reduction in the yield was quite significant in check plots to warrant the application of chemicals for the control of cotton pests.

Statistical analysis confirmed the effectiveness of some of the insecticides (particularly Toxaphene) used here in the control of the cotton insects experimented with.

The chemicals used here as well as some newer ones will no doubt succeed in keeping such harmful pests under control and save a considerable amount of the crop.

SUMMARY

Salitol, Parathion, Cotton-dust, Toxaphene and Chlordane were compared for the control of some of the main cotton insect pests under field conditions. Each of the used insecticides was applied on ten replicated plots, 4 square kassabahs each, which were artificially inoculated with cotton leafworm egg-masses. Each plot received ten egg-masses of about 3000 eggs during the season. Toxaphene 2% was found superior to other materials in this concern.

Statistical analysis proved that all the used chemicals are effective in the control of both the cotton leafworm and the leafhoppers to various degrees. Their effectiveness in the control of the cotton boll worms is however not so definite.

Results arrived at here encourage the use of these and other chemicals for the control of such cotton insects as those experimented upon at present.

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STUDIES ON THE HEARTBEAT OF THE GERMAN COCKROACH, *BLATTELLA GERMANICA* L.

[*Orthoptera: Blattidae*]

(with 10 Tables)

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I. INTRODUCTION

Our imperfect knowledge of the physiology of the insect heart undoubtedly is partially owing to the fact that the heart is very fragile and can only be examined in an isolated state with the utmost difficulty. Complete isolation is not feasible, as the alary muscles cannot function without connections to the body wall. Some authors have succeeded in keeping the heart beating after the removal of all other organs, so that only the dorsal wall of the body remains with the heart attached there to. In this way LEVY (1928) examined the influence of ions upon the heart of fly larvae, but the frequency of the heartbeat did not remain constant in his experiments and consequently quantitative conclusions were not possible. In a similar way YEAGER and HAGER (1934), YEAGER and GAHAN (1937) and YEAGER (1938) studied the surviving heart of *Periplaneta americana* L. and *Prodenia eridana* in a physiological solution at a constant temperature. YEAGER and GAHAN, HAMILTON (1939), CRESCITELLI and JAHN (1938) and DE WILDE (1947) also succeeded in mechanically recording the activity of the insect heart.

Mechanical recording is doubtless an excellent means of studying some problems relating to the functions of the heart but it is not a method that can always be recommended. For instance, if the influence of drugs, ions and toxic substances over prolonged periods of time has to be studied, it is necessary to keep the heart beating in a normal rhythm for hours and as mechanical registration hinders the

fragile heart muscles, this cannot always be achieved. In such cases observations by Yeager's method are more suitable.

YEAGER's experimental conditions are not fully satisfactory, for while the heart frequency of *P. americana* in the intact insect is 80-110 per minute at 30°C. (BRÜCKE, 1925) YEAGER states, that the frequency in his preparations soon falls to 40-50 per minute. However, by YEAGER's method it has been possible to obtain experimental conditions, in which the heart maintains a normal rhythm over prolonged periods of time.

There is no general agreement as to the origin of the heartbeat in insects, whether it is neurogenic or myogenic in origin. Considering the lack of uniformity in the physiology and neuromuscular morphology among insects, there is perhaps no reason to assure that the origin is the same in all insects.

Anatomical evidence suggests that in some cases at least, the heartbeat is myogenic. This is based on the observation that the hearts of the dragonfly, *Anax junius* (MALUF, 1935) and of the silk worm *Bombyx mori* (KUWANA, 1932), continue to function in the absence of nervous connection. It is, however, difficult to demonstrate beyond doubt that all intrinsic ganglion cells are absent in a heart preparation and consequently that the heart muscle alone initiates the contraction wave.

The insect heart is commonly innervated by a pair of lateral nerves that runs along the heart giving off branches to the heart wall, the alary muscles and the lateral vessels if present. Contributing to these lateral nerves are fibres from the paired cardiac ganglia of the stomatogastric system and nerves from the ganglia of the ventral nerve cord (WIGGLESWORTH, 1939). In the cockroach (ALEXANDROWICZ, 1926) the lateral nerves consist chiefly of processes from ganglion cells scattered alongside the nerve. ALEXANDROWICZ suggested that these elements form the autonomic apparatus, whereas segmental nerves carry accelerator fibres from the central nervous system, and sensory filaments reach the heart on its dorsal side from sensory branches directed toward the dorsal body wall.

MC INDOO (1945), found out that lateral cardiac nerves are not present in *Prodenia eridania*, but in the abdomen eight pairs of segmental cardiac nerves innervate the heart. Mc Indoo considers the cockroach heart to be innervated well while that of *Prodenia eridania* is poorly innervated.

The innervation of certain insects' hearts can of course be responsible for the control and regulation of the heartbeat even if necessary for initiating the contraction. The temperature characteristic has been presented as evidence for a neurogenic heartbeat. The pharmacologic evidence supporting either view is unsatisfactory because the diagnostic agents so useful in vertebrate studies do not necessarily induce the same response in insects. Insect pharmacology is not sufficiently advanced to permit the use of blocking agents, and specialized stimulants with assurance that the desired effect is to be achieved. It has been suggested by PROSSER (1942) that among arthropod hearts, those accelerated by acetylcholine are neurogenic, those inhibited are myogenic, and those unaffected are non-innervated.

DAVENPORT (1949) was led by the pharmacological evidence to suggest that the heart of *Stenopelmatus* which is well innervated, possessing ganglia closely invested to the heart muscle, is thus of neurogenic origin. NEEDHAM's generalizations (1950), that the hearts of immature insects are myogenic whereas the hearts of adult insects are neurogenic are not accepted by various authors and need to be checked by further experimentation.

KRUGSMAN and KRUGSMAN (1950) conclude that the hearts of insects, in common with most arthropoda, possess neurogenic pacemakers with adrenergic properties, giving off impulses with their own rhythm to the cardiac musculature and that the spontaneous rhythm is controlled by cholinergic accelerating nerve.

DE WILDE (1948) has discussed the possibility that a state of tension is the factor responsible for initiating the beat and maintaining rhythmicity.

II. MATERIAL AND METHOD

Adult males as well as nymphs of the German cockroach, *Blattella germanica* L., were used as the test insects. The body weight of these insects averaged 55 mg. with a standard deviation of 1 mg. The insect under test was placed in a glass tube 3 cm. long and about 3 mm. in diameter. The tubes were set in notches specially prepared in a wooden block placed on the stage of a binocular microscope. Each glass tube being drawn narrow at one end; imprisoning the insect while the other end of the tube being securely stoppered with a specially fitting metal rod that could be adjusted to corner the insect, under observation, in any desired position, without damaging or crowding it.

Special technique being devised to catch and coax the insects into the observation glass tubes without touching them; a funnel was used to cover the rearing cage and the insect ultimately would climb through the narrow end of the funnel which is connected to a glass tube. A water cell was interposed to cool the radiation from the spot light type of microscope lamp that was used for illumination.

After an interval of a few minutes to allow the insects to become quiet, the rate of their heartbeat was measured visually under the microscope with the aid of a stopwatch and a hand tally.

It was noted that the best part to record the heartbeat was the region of the metathorax to the second abdominal segment, where the integument is quite light and transparent revealing a good view of the heart below.

In case of tests done to study the effect of CO₂ on the heart beat, a continuous flow of the gas was provided from commercial cylinders to supply the required percentage of CO₂ in the atmosphere of the insect.

For injections of fluids, the insects were just immobilized with carbon dioxide anaesthesia under room temperature, then injected through the intersegmental membrane behind the fifth abdominal terga and close to the lateral border so as

to avoid any mechanical effect on the heart. Sometimes this treatment caused the insect to exhibit a series of writhings and to become hypersensitive to stimuli, but this effect disappeared within one minute. Specially prepared, electrically drawn glass needles attached to a metal syringe mounted in line with a micrometer, were used. The injecting apparatus is settled on a wooden stand specially devised, to avoid any unnecessary damage to the insect while injections are given.

III. NORMAL RATE OF HEARTBEAT

The heartbeat in insects generally originates at the posterior end of the dorsal vessel. This beat propagates forwards as a peristaltic wave. The speed of propagation varies among insects and at different times in the same insect. The beat may be so rapid that the entire heart appears to contract simultaneously as in the case of *Periplaneta*, or it may be so slow that three waves of contraction are noticed as in the case of *Corethra* larvae, in which the contraction wave moves at not more than 1 mm/sec. (TZONIS, 1936). LASCH (1913) indicated that in the larvae of *Lucanus cervus* the rate of propagation is 19.5 to 44.5 mm./sec. with an average of 27.2 mm./sec. These differences in propagation speed of the heartbeat may be associated with differences in the inherent elasticity of the dorsal vessel or in the tonicity maintained, as well as with differences in the rate of propagation of the excitatory state.

The contraction rate of the dorsal vessel is affected by a variety of factors such as the general metabolism, stage of development, temperature and the presence of various agents. Consequently "the normal" value may be a hypothetical figure. Different individuals of the same species may have markedly different pulse rate, but in a given individual the rate is fairly constant under normal conditions (MALUE, 1939 b).

During the larval development of *Sphinx ligustri* the contraction rate shows a progressive decrease, the rates being 73-108/min. for the first two instars, 50-79 for the third, 33-56 for the fourth and 28-55 for the fifth (NEWPORT, 1837). MASERA (1933) observed that during the inactive period prior to each moult the heart rate decreases in *Bombyx mori*.

TABLE I

Normal rate of heartbeat of *Blattella germanica*.

Nymphs of less than 140 mg.	Nymphs of 140-150 mg.	Nymphs of 155 mg. or more	Adult female 180 mg. average	Adult female 156 mg. average
260-220/min. 310-280/min.	220-180/min. 260-240/min.	200-180/min. 240-220/min.	180-140/min. 190-160/min.	160-120/min. 180-140/min.

In the present investigation, several recordings were taken of the rate of heartbeat in *Blattella germanica* under the normal conditions of the insect. The individual insect tested, was placed in the glass tube, allowed to regain its normal pulsation rate by letting it remain for few minutes before the beat was counted.

It was noted that the larger the size of the cockroach the slower was its rate of heartbeat. Also female roaches tended to record comparatively higher rates of beat than males irrespective of the difference in weight.

During the conduction of these tests, some points were noted. In many instances it was observed that the heart would pulsate rhythmically for a certain period of time, then it would stop and for a short interval the pace would slow down considerably, sometimes reaching 40-50% of the normal rate of pulsation, before it resumed its normal beat. In several tested insects, especially nymphs, the author would notice certain dark objects floating in the blood stream inside the heart cavity. The author's guess was that these objects could very well be parts of the broken down endoskeleton or of the cuticular lining as the insect would be ready for moulting.

During each test it was frequently noticed that struggles or movements of the alimentary tract produced marked irregularities or even brief cessations of heart activity.

IV. EFFECT OF STARVATION AND FATIGUE

Tests were conducted to study the effect of starvation in relation to the rate of heartbeat. Individual insects were placed in separate glass tubes, the normal rate of beat was recorded, then the insects were left over periods of time; extending in some cases to 14 days, during which time the insects under examination were denied any source of food or water. The heartbeat rate was checked from time to time and the following table shows some of the data collected (Table II).

It was clearly demonstrated that starvation had a marked effect upon the rate of heartbeat. The data collected showed that there was a definite decrease in the rate as the time of fasting was prolonged. In some insects the decline in the rate was more definite and clear after the first 48 hours rather than after shorter or longer periods of fasting. The author's explanation for this observation is that the insect had to utilize its stored fat substances with the result of picking up in its pace of heartbeat approaching the normal rate. Many insects died away after a period of fasting varying from 5-14 days. Females were found to stand less time of fasting and starvation than either males or nymphs.

There was some variation in the effect of starvation upon different cockroaches; one nymph would register a rate of 116 per minute after 24 hours of starvation while another would show the same rate of normal beat after 5 days of fasting.

TABLE II

Starvation and rate of heartbeat in Blattella germanica.

Test insect (average weight)	Rate of heartbeat/minute					after more than 7 days
	Normal	1 day later	2 days later	3 days later	5 days later	
Nymph. (150 mg.) ...	260	180	110	140	140	120
Nymph. (160 mg.) ...	200	190	160	120	120	140
Nymph. (145 mg.) ...	290	270	180	180	180	160
Male (155 mg.) ...	260	180	190	120	100	80
Male (165 mg.) ...	240	190	100	120	110	90
Female (175 mg.) ...	180	120	140	120	110	—
Female (180 mg.) ...	170	140	140	120	110	—

More series of tests were carried out to investigate the effect of fatigue and activity upon the rate of beat. The individual insect, after being placed in the glass tube, was not allowed to settle down and rest. The method used to cause this forced activity was simply by rolling the glass tube slowly, thus compelling the insect inside to keep trying vigorously to right its position.

From the results obtained, it was indicated that there is a marked correlation between the activity of the insect and the rate of its heartbeat. There is a definite increase in the rate especially during the first 5 minutes of forced activity, followed by a tendency towards resuming the normal level. Most insects, under these test conditions, were recording rate of beat comparable with their normal rate, after 20-30 minutes of forced activity (Table III).

TABLE III

Effect of activity and fatigue on heartbeat of Blattella germanica

Insect tested	Normal rate/m.	Rate after activity of				
		2 min.	5 min.	10 min.	20 min.	30 min.
Nymph (small)	260	290	280	260	260	240
Nymph (medium)	265	280	290	220	200	210
Nymph (large)	240	260	300	280	240	220
Nymph (medium)	250	280	290	270	250	240
Male	240	280	280	250	230	200
Female	190	220	250	190	200	160
Female	200	230	260	240	180	180
Male	260	270	310	270	200	240

It was noted that the rhythm of the heartbeat was more regular during the resting state of the insect than after any period of forced activity, when the rhythm would be interrupted by longer pauses in systolic phase of the heart.

Some insects, nymphs and adults, were left secluded in the observation tubes for longer period of time with no source of food or water. Few of these lasted over 14 days of fasting, at the end of each period they "died". They gave no response to any inducement of external stimuli; mechanical or thermal, yet when examined under the microscope it was clearly observed that the heart was still beating rhythmically at a much lower rate, i.e. of half or one third its normal rate. Aside from this heart activity and some feeble shifting movements of the internal organs, the insect would be considered definitely dead.

It seems that the long period of starvation had affected the insect to the extent that no source of energy was available for the necessary muscles of locomotion while the heart was still being provided with some last source, keeping it going a little while longer.

In some cases the heart kept working for as long as 2 hours after the last sign of life in the insect had disappeared.

V. EFFECT OF CARBON DIOXIDE UPON RATE OF HEARTBEAT

WALLING (1906) found that upon exposure of intact grass-hoppers to carbon dioxide, the respiratory movements cease in 20-60 seconds, but the heart action continues about 6 hours longer. In fresh water after exposure to CO₂ for 48 hours, the heart action in grasshoppers is resumed, but their respiratory action is not. Isolated heart preparations directly exposed to CO₂ cease to beat in 30-60 seconds. BEARD (1950) observed that exposure of intact *Oncopeltus* to CO₂ results in cessation of heart activity coincident with loss of body movements. Upon recovery from CO₂ anesthesia, the heart activity is usually resumed suddenly with full amplitude and rate of beat. Walling also found that the action of carbon monoxide on the heartbeat of grasshoppers is similar to that of carbon dioxide but there is no recovery after 48 hours of exposure. STAUTET and AUDIBERT (1944) observed that in larvae of *Culex* and *Theobaldia* kept submerged in water, asphyxia resulted in a rapid decrease in heart rate and an irregularity in the beat.

Several cockroaches, mainly last stage nymphs, were subjected to CO₂ in order to study the effect of the gas upon the rate of heartbeat. Carbon dioxide was found to have a clear effect upon the rate of heart of *Blattella germanica*. Table IV, being an example of the results obtained from such run of tests, indicates how the gas has caused complete cessation of the heartbeat within 20-40 seconds, only to be resumed again when the flow of CO₂ ceases. The rate of flow of CO₂ was averaging 5 litres per minute.

TABLE IV

Effect of CO₂ upon rate of heartbeat in Blattella germanica

Normal rate	Rate under CO ₂ exposure	Rate after recovery from CO ₂ anesthesia			
		1 m. later	2 m. later	3 m. later	4 m. later
220-240/m.	250-270/m.	90-110/m.	140-170/m.	190-210/m.	230/m.
200-220/m.	240-255/m.	140-150/m.	180-190/m.	200-210/m.	210/m.
180-200/m.	230-250/m.	080-100/m.	120-140/m.	160-180/m.	215/m.
190-220/m.	240-260/m.	080-090/m.	110-130/m.	150-180/m.	220/m.
210-240/m.	240-265/m.	110-125/m.	140-160/m.	180-210/m.	240/m.

The rate of heartbeat of such treated insects usually picks up gradually till it reaches the normal rate within the first three minutes. There are yet some variation in relation to the degree of susceptibility and tolerance of the insects to CO₂ and also in the time needed to recover the ill effects of the gas.

From these effects, one is led to assume that the origin of heart activity in roaches, as well as in other insects, might be myogenic rather than neurogenic, as some authors believe; since the heart muscles are inactivated by the effect of CO₂ following an ordinary state of "knock out".

During the above and similar observations the author came to notice a definite phenomenon concerning certain respiratory mechanism. It was found that the longitudinal tracheal trunks on both sides of the dorsal vessel go through a process of pulsation similar to the heart pulsation; thus collapsing longitudinally in a rhythmic fashion almost keeping pace with that of the heart. This was particularly observed in the region of the thorax, notably in case of activated insects and in those going through a state of rest after a period of forced activity. This is also true in insects suffering effects of anesthesia by CO₂ gas.

When CO₂ had been introduced, the insect showed signs of excitation and agitation expressed by sudden jerks of the body accompanied by kicking of the legs. As to its effect on the heart, it has been observed that the gas has, in the first few seconds, a marked effect associated with a definite increase in rate of heartbeat which does not last more than seconds, then a steady decrease in rate follows, thus taking a period of 30-50 seconds in order to bring complete cessation of apparent heart activity. After preventing the flow of CO₂, it usually takes the heart about 40 seconds in order to start acting again; presented by very feeble incomplete pulses that are widely separated in time at first. The duration of cessation intervals of heartbeat is gradually decreasing until the heart resumes its normal rate that usually takes place after an average of three minutes.

VI. ANOXIA AND HEARTBEAT

Some tests were undertaken to examine the effect of submerging the insect in water upon the rate of heartbeat. Individual cockroaches (nymphs) were placed in observation tubes and after recording the heartbeat water was allowed to fill the tube gradually till the insect was totally submerged in water. The following table illustrates some of the data collected.

TABLE V

Heartbeat of Blattella germanica under water submersion

Normal rate	Rate under submersion			
	after 1 min.	after 3 min.	after 5 min.	after 7 min.
280/min.	180/min.	120/min.	60/min.	20/min.
300/min.	220/min.	160/min.	80/min.	42/min.
310/min.	210/min.	180/min.	40/min.	20/min.
260/min.	200/min.	140/min.	80/min.	30/min.

From the above data and from the results of similar tests it is clearly demonstrated that the heart activity of *Blattella germanica* is directly affected by submerging the insect completely in water. Most individual cockroaches took an average of 5-7 minutes for their heart to stop beating in systolic state. The gradual decrease in the rate of heartbeat in nymphs under water illustrates the effect of such condition upon the heart action. The insects showed normal rate of heartbeat if taken again to air although this required few minutes to reach the normal rate.

It is the author's guess that it is either the direct effect of the resistance of the new medium, being water here, upon the respiratory mechanism of the insect or the partial absence of oxygen from the atmosphere of the insect, which induced such a clear sudden drop in the rate of heartbeat.

TABLE VI

Heartbeat of Blattella germanica submerged in oxygen-free water

Normal rate	Rate in water			
	1 min. later	3 min. later	5 min. later	7 min. later
260/min.	195/min.	120/min.	85/min.	40/min.
245/min.	200/min.	140/min.	95/min.	60/min.
225/min.	180/min.	120/min.	85/min.	30/min.
240/min.	170/min.	130/min.	90/min.	50/min.
280/min.	220/min.	160/min.	110/min.	65/min.

In order to illustrate further such relation, insects were submerged in previously boiled and cooled water to avoid the presence of soluble air. The results obtained tend to support the view that it is more or less the direct effect of anoxia upon the heart activity of the insect rather than the presence of water as illustrated in Table VI.

VII. BLOOD DILUTION IN RELATION TO HEARTBEAT

The role of blood pressure in the mechanism of circulation is quite different from that in animals possessing a closed blood vascular system. It has been maintained, with dubious validity, that in a closed system positive pressure alone is adequate to maintain movement of the blood, whereas in an open system the forces of propulsion must be associated with forces of aspiration for circulation of fluid to take place.

A number of investigators have reported formulas for salt solutions favourable for maintaining contractions in isolated heart preparations. The effects of sodium, potassium and calcium have been studied in *Gryllus domesticus* (BERGERARD, 1947) and in the larva of *Galleria mellonella* (DREUX, 1950). Solutions having a Na/K ratio of less than 8 arrest the heart in systole. Higher ratios increase the rate of beat and decrease the amplitude. Solutions having a $a(\text{Na} + \text{K})/\text{Ca}$ ratio of less than 3 cause diastolic arrest. Higher ratios retard the rhythm and decrease the amplitude of beat. Hypertonic physiological solutions retard the rate, increase the amplitude of beat and, if sufficiently concentrated, arrest the heart in diastole. Hypotonic solutions have the opposite effect, and in the end cause systolic standstill. These observations are in contrast to those of KOZHANTCHKOV (1932), with *Blatta orientalis*, that modified RINGER's solution low in concentration decreased the heart rate and lengthened the resting phase until in 0.6% solutions the heart stopped in diastosis, whereas hypertonic solutions increased the rate until systolic standstill occurred in 14% solutions.

In order to study the effect of varying the blood pressure in *Blattella germanica*, through injecting quantities of water or saline solutions, upon the heart activity special technique was devised to introduce certain amounts of solutions into the body of the insect. With the help of a microsyringe mounted in line with a micrometer nymphs of *Blattella germanica* were injected with various amounts of the solutions. The preferred site of injection was between the fifth and sixth abdominal segments at the ventrolateral side in order to avoid any mechanical injury to the insect heart.

From the results obtained (Tables VII-IX), it seems that there is a certain effect of diluting the insect blood (hence changing blood pressure), upon the rate of heartbeat. There was a tendency towards an increase in the rate of heartbeat corresponding with the relative increase in the blood volume up to 1 c.mm. It was

TABLE VII-IX

Effect of water injections upon the heartbeat of Blattella germanica

TABLE VII

Amount of water introduced 0.25 c.mm.

Normal rate	Rate after water injection			
	1 min. later	3 min. later	5 min. later	10 min. later
265/min.	290/min.	220/min.	280/min.	270/min.
260/min.	290/min.	280/min.	270/min.	265/min.
275/min.	310/min.	290/min.	285/min.	280/min.
288/min.	310/min.	295/min.	290/min.	280/min.
240/min.	260/min.	255/min.	250/min.	230/min.

TABLE VIII

Amount of water introduced 0.50 c.mm.

Normal rate	Rate after water injection			
	1 min. later	3 min. later	5 min. later	10 min. later
250/min.	300/min.	295/min.	290/min.	290/min.
245/min.	310/min.	285/min.	290/min.	290/min.
260/min.	310/min.	300/min.	300/min.	290/min.
270/min.	295/min.	290/min.	295/min.	290/min.
240/min.	280/min.	260/min.	260/min.	260/min.

TABLE IX

Amount of water introduced 1 c.mm.

Normal rate per minute	Rate after water injection			
	1 min. later	3 min. later	5 min. later	10 min. later
240/min.	290/min.	310/min.	310/min.	320/min.
260/min.	300/min.	310/min.	290/min.	295/min.
270/min.	320/min.	300/min.	295/min.	300/min.
265/min.	310/min.	320/min.	300/min.	310/min.
260/min.	300/min.	310/min.	300/min.	310/min.

TABLE X

*Effect of saline solution upon rate of heartbeat**(a) Amount inoculated 0.25 c.mm. of 5% NaCl*

Normal rate per minute	Rate after inoculation			
	1 min.	5 m. later	10 m. later	30 m. later
240	260	270	275	260
220	255	270	260	250
260	280	240	255	280
240	275	230	250	260
270	290	260	255	280

(b) Amount inoculated 0.5 c.mm. of 5% NaCl

Normal rate per minute	Rate after inoculation			
	1 m. later	5 m. later	10 m. later	30 m. later
220	250	240	200	160
245	260	250	210	180
235	280	250	205	175
218	240	210	190	140
260	280	240	220	—

(c) Amount inoculated 1 c.mm. of 5% NaCl

Normal rate per minute	Rate after inoculation			
	1 m. later	5 m. later	10 m. later	30 m. later
230	250	190	160	—
235	265	210	210	190
260	290	220	190	—
255	260	215	180	—
245	275	230	210	180

to be observed that the increase in the rate was more pronounced in first readings taken after the injection, yet this remark was not necessarily true in cases when amount of injected water approximates that of 1 c.mm. This could be due, among other factors, to the shock of operation itself, hence the rate though remaining high in comparison to the "normal", yet it tended to decline slightly minutes later. In experiments, where the amount of introduced diluting fluid exceeded that of 1.5 c.mm., the heartbeat rate although registering a primary definite increase yet the heart stopped in diastole after 3-5 minutes. In cases when some of the injected amount of water oozed out again from the inoculation site, results of such cases were excluded from the test.

VIII. EFFECT OF INJECTING SALINE SOLUTIONS UPON HEARTBEAT

For reasons of comparison, other roaches were injected with saline solution (5% NaCl) in order to see its effect upon the rate of heartbeat. Doses varying from 0.25 c.mm. up to 1 c.mm. were used. Average sized nymphs were mainly chosen to run the test. In experiments where the amount of saline solution inoculated was 0.25 c.mm. per each roach, the results obtained (Table X) demonstrated the behavior of the heart in relation to the introduction of such solutions. The variation in the rate of heartbeat under such condition was not essentially clear; except the tendency to record a slightly higher rate (6-8% of the "normal" value) following the process of inoculation. Some insects were found to maintain this tendency 30 minutes later.

When the doses of saline solution were increased, i.e. 0.50-1 c.m., the effect was quite noticeable. During the 30 minutes observation time of the test, the rate was declining steadily until the heart recorded half as much as the "normal" rate of heartbeat. Several insects failed to maintain such a lowered rate and their heart stopped completely in a diastole state.

It seems that the extra sudden salinity in the insect blood caused a certain physiological disturbance in the tissues, tending to draw water necessary to balance the new hypertonic state from the insect tissues including the body wall of the heart, the latter thus acquiring less elasticity and recording lower rates of heartbeat.

IV. SUMMARY

(1) The "normal" rate of heartbeat in the German cockroach, *Blattella germanica*, is found to fluctuate between 140-300/minute depending upon the size and stage of the insect. Generally there is a tendency to register higher rates of heartbeat in smaller insects.

(2) Starved cockroaches demonstrate lower rates of heartbeat in varying degrees depending upon the time and extent of fasting. Likewise, fatigue is a factor that would cause a clear drop in such rate.

(3) Carbon dioxide was found to interfere with the "normal" rate of heartbeat. Although it causes increase, due to stimulation, during the early moments of exposure; yet after recovery from its "knockout" effect, the heart registers a much lower rate (30-40% the normal) only to increase gradually reaching the "normal" value in four minutes.

(4) Absence of atmospheric Oxygen has a direct effect upon the heart activity of the insect; since it has been demonstrated that insects submerged in water would register much lower rates of heartbeat (down to 10% the "normal").

(5) Injections of water into the body cavity induces higher rates of heartbeat particularly when doses injected approximated 1 c.mm., while injections of similar amounts of saline solutions caused a decrease in the rate and later a complete standstill of the insect heart in diastole state.

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**THE CHEMICAL COMPOSITION
OF THE LARVAE OF THE PINK BOLLWORM,
PECTINOPHORA GOSSYPIELLA SAUNDERS,
BEFORE AND DURING DIAPAUSE**

[*Lepidoptera : Gelechiidae*]

(with 13 Tables)

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I. INTRODUCTION

In insects, the changes in composition which occur during the stage of diapause proper have been investigated in a few cases only. On the other hand, the changes occurring during starvation have been dealt with by many authors (WIGGLESWORTH, 1942; LUDWIG, 1950; NEWTON, 1954; etc.). The fresh weight, the dry weight, the water content and the amounts of ash, free fat, glycogen, protein and non-protein nitrogen are the main items which have been worked out in such cases.

Very few data are available on the composition of the pink bollworm *Pectinophora gossypiella* S. before and during diapause. These data include those of GOUGH (1919), SQUIRE (1940) and FIFE (1949). The first author found a regular decrease in the fresh weight of the resting larvae from February to July. SQUIRE (1940) and FIFE (1949) observed that the resting larvae have a lower moisture content than the active ones, and in addition Squire recorded a higher fat content in the resting stage.

For some other insect larvae the composition during periods of rest, whether "diapause" or "hibernation", has been compared with that of active larvae. An example of such work on larvae are those carried out by TIMON-DAVID (1928) and KOZHANTSHIKOV (1935) on *Pyrausta nubilalis*, by SACHAROV (1930) on *Euproctis*

chrysorrhoea, who all found a higher fat content and a lower water content in the diapausing larvae; by SHIBATA (1933) on *Calandra*, by STRELNIKOV (1936) on *Loxostege sticticalis* and by WALOFF (1949) on *Ephestia elutella*, who all reported a lower water content, while the last author also reported a loss of fresh weight and fat. NEWTON (1954) working on *Popillia japonica* found, besides a loss in fresh weight, also observed by the above mentioned authors, a fall in glycogen content.

A general lowering of the metabolic processes during diapause was reported by COUSIN (1932) in the larvae of *Lucilia*. The lowered oxygen consumption in diapausing larvae was not accompanied by a disruption of the cytochrome oxidase system (LEVENBOOK, 1951; McDONALD and BROWN, 1952; LUDWIG, 1953; LUDWIG and BARSA, 1955) as is the case in diapausing pupae (WILLIAMS, 1948; WIGGLESWORTH, 1953).

The changes in composition of the body during diapause in the adult stage have been studied by many authors like TOWER (1906) and BREITENBECKER (1911) on *Leptinotarsa decemlineata*, BODINE (1923) on grasshoppers and TOWNSEND (1926) on cold blooded animals in general, who all observed a loss in water content during diapause; moreover by BUXTON (1932 and 1935) on *Culex pipiens*, by BUSNEL and DRILHON (1937) on *Leptinotarsa* and by AGRELL (1951) on *Phalera bucephala* and *Endromis versicolosa*, who all found a loss in fat content.

The changes in composition of insect larvae during simple starvation have recently been the subject of an extensive investigation by NEWTON (1954) on post-diapause third instar larvae of *Popillia japonica*. Earlier, this problem had been studied by BUXTON (1930) and MELLANBY (1932) using as material larvae of *Tenebrio molitor*, by BELLUCI (1939) who used *Popillia japonica* and by WIGGLESWORTH (1942) using *Aedes aegypti*. The main results emerging from these studies show a considerable loss of fat, next to losses in glycogen and protein, while the water content remained constant or even increased. Adult insects of many species and some nymphs have been also subjected to shorter or longer periods of starvation by a number of authors and the subsequent changes in one or more of the body constituents were ascertained. Such authors are SLOWTZOFF (1904, 1905 a,b and 1909) who worked on *Melolontha*, *Bombus terrestris* and *Geotrupes stercoralis*, HELLER (1926) on *Deilephila euphorbiae*, KELLER-KITZINGER (1935) on *Apis mellifica*, LAFON (1941) on *Phormia regina*, WIGGLESWORTH (1949) on *Drosophila melanogaster* and LYDWIG (1950) on *Chortophaga viridifasciata*. The results of these authors indicate that glycogen and other carbohydrates are the main sources of energy during the initial stages of starvation, whereas fat is used up after the glycogen supply is exhausted. The role of protein as a reserve substance varies in different insect species.

Hardly any data are available on the changes in the composition of the blood of the diapausing larvae other than those of LUDWIG (1954) on the third larval instar of *Popillia japonica*, who found that both protein nitrogen and non-protein nitrogen were higher during diapause. As to the changes in composition

of blood in insect larvae during starvation, the results obtained on *Deilephila euphorbiae* (HELLER and MOKLOVSKA, 1930) on *Culex pipiens* and on *Aedes aegypti* (WIGGLESWORTH, 1938) show evidence for the role of blood as a store of protein and of organic materials, which are reduced in starvation. On the other hand the results on *Popillia japonica* (LUDWIG and WIGMEISTER, 1953; NEWTON, 1954) showed no change in water content or protein content, but an increase in amino acids and glucose and a temporary increase in fat.

From the above literature, a general picture of the chemical events happening before and during diapause in insects can be formed. Comparative analyses of active larvae and diapausing larvae at different intervals have shown that the latter have a lower fresh weight, attributed in many cases mainly to the experimentally established loss of water. A higher fat content has also been found in most cases and it has been shown that during the diapause stage a big part of this fat is more or less gradually mobilised. The almost complete disappearance of glycogen has been proved only in one case (SLOWTZOFF, 1905a). No data at all are available on the changes undergone by the nitrogenous substances. The data available on the nitrogenous substances in blood (LUDWIG, 1954) show an increase in the protein nitrogen in the diapausing larvae, as well as an increase in non-protein nitrogen in diapausing larvae.

The picture of the metabolic changes during diapause is very similar to that of such changes during starvation. In the latter case however, the water content, where investigated, was found to remain constant. The utilisation of fat seems usually to be accompanied with or preceded by a complete disappearance of the stored glycogen, whereas in a few adult insects and larvae also protein was found to be utilised. Some changes in the amounts of protein, fat and reducing substances in the blood have been registered to take place during starvation.

The knowledge of the changes in composition of the body during the transformation of larvae to pupae has been summarised by NEEDHAM (1950), WIGGLESWORTH (1953) and by BUCK (1953). The most salient changes during this transformation have been found to be a loss of fresh weight, in some cases a loss of dry weight and a great loss of water, which later was thought to be responsible for most of the loss in fresh weight. Also, a loss of fat has been recorded and a lowering of the respiratory quotient to such values as indicate a transformation of fat to other substances. As to the nitrogenous substances, the results of numerous authors, summarised by BUCK (1953) as well as those of ANDERSON (1948) working on *Popillia japonica*, show that the amounts of protein nitrogen of the early pupae are less than those of the late larvae, whereas the values for nonprotein nitrogen are high. ANDERSON attributed this shift in nitrogen to the disintegration of the tissues of the mature larvae at pupation. LUDWIG, working on the distribution of nitrogen in the blood of *Popillia japonica*, found that after the change from larvae to pupae had taken place, the blood contained more protein nitrogen, but less non-protein nitrogen. Of the latter, the amino nitrogen had also decreased but little, while an increase

was found in uric acid- and urea nitrogen. Ludwig attributed the rather constant values for the amino nitrogen, also found by other workers, to the removal of amino acids from the blood at the same rate as they are formed from disintegrating tissues.

The information on the composition of the larvae of the pink bollworm before and during diapause summarised above are far from being complete. In connection with the results of SQUIRE (1940) on this species and of WALOFF (1949) on *Ephestia elutella* (who concluded that the termination of the diapause phase of this insect is not reached until a certain loss in weight had occurred), it was thought possible that the length of the diapause period in the pink bollworm might depend on the amount of available food reserves, especially of fat. The end of diapause, followed by pupation (EL-SAYED and RUSTOM, 1960), might be expected to take place at a certain "critical" level of the fat reserve substance. Therefore, in the present work the amounts of fat in the resting larvae were determined at different intervals during this stage and compared with the amount of fat found in the active larvae just before entering diapause. In order to get a more complete picture glycogen, protein nitrogen and non-protein nitrogen were also determined at these different intervals, as well as the fresh weight, the water content and the ash. Furthermore, serial analyses were carried out on the blood of both the active and resting larvae, at different ages of the latter, to see whether it possesses any storing function attributed to insect blood by WIGGLEWORTH (1938). It was also thought interesting to see whether pupae resulting from active larvae show any difference in composition from pupae resulting spontaneously from the larvae on terminating the normal period of diapause.

II. MATERIAL AND METHODS

Active fourth larval instar, which had been feeding regularly, were collected from *Hibiscus esculentus* (bamia) in December. The host plant had a water content of 68% and an oil content between 14.7 and 17.3% with an average of 15.65%. Several lots of these larvae, representing the active stage, were analysed immediately. The remaining active larvae were put in cotton fibres inside rearing boxes, under conditions of the laboratory and were left to enter the resting stage. The previous work on this pest (EL-SAYED and RUSTOM, 1960) had shown that the average duration of the resting stage of larvae brought to the laboratory in December to be 94.8 days, reckoned from the moment of transition from the active to the resting stage. This transition had been considered to take place 30 days after collection.

Analyses of the larvae were made at intervals during the resting stage; the first analysis was made at the end of 10 days on newly resting larvae, the second after another 35 days, more or less at the middle of the resting period and the third after another 35 days on larvae approaching pupation.

The analyses at each age were made on 2-3 groups of usually 15-30 larvae, taken at random from the rearing boxes. The fresh weight of each group was determined immediately, after which the larvae were dried in the drying oven at 110°C till constant weight. Following the procedure of NEWTON (1954) the dried material was kept in a dessicator till the analyses took place. In some preliminary experiments it was found that material kept under these conditions showed no difference from that analysed immediately, *i.e.* without previous drying.

Analyses were made to determine the following items: ash, glycogen, free fat, total nitrogen, non-protein nitrogen and by difference protein nitrogen. Moreover at each age blood was collected from a number of larvae as will be described below.

The water content was determined as the difference between fresh and dry weights. The ash content was determined by weighing the residue after ignition on a Bunsen burner. The ether-soluble fraction (free fat) was estimated by means of a micro-Soxhlet apparatus following the procedure described by NEWTON (1954), and extraction was accomplished with anhydrous ethyl ether. For the determination of total nitrogen by the micro-Kjeldahl apparatus, GUNNING-ARNOLD's method of digestion was followed (KOCH and HANKE, 1948). In the distillation process, the receiver fluid used was a 2% solution of boric acid, with bromocresol green as indicator. Back titration was carried out against 0.02 N sulphuric acid. By multiplying the number of cc. of acid used by 0.28 the amount of nitrogen in the portion of material used was obtained in mg. Non-protein nitrogen was determined following the procedure outlined by HOPF (1938). The amount of nitrogen in the filtrate was estimated by the micro-Kjeldahl apparatus. To obtain the protein number the figure obtained for the non-protein nitrogen was subtracted from that of the total nitrogen and the difference (protein nitrogen) was multiplied by the protein conversion factor 6.25, found by TASSONI (1952) to be "justifiable" in the case of insects. Glycogen was determined by the method of DITMAN and WEILAND (1938), with the exception that material oven dried at 110°C was used here, instead of material dried in a vacuum oven at 55°C. After hydrolysis of glycogen determination of the reducing power followed, using the method of HAGEDORN and JENSEN (1922). The amount of glycogen was calculated from the glucose value by multiplying the latter by the factor 0.927 (BABERS, 1938).

For the presentation of the results, the amount in mg. of each substance found in each group, was divided by the number of larvae in this group, in order to obtain the mean amount in mg. per larva. The extreme values found for this mean are given in the Tables as "range". Moreover the "average amount" per larvae given in the Tables, was obtained by dividing the sum of the mean values by the number of groups used in the determination.

Blood was collected from groups of diapausing larvae at each of the ages mentioned above. From each larva, blood was obtained by removing one of the thoracic legs with fine forceps and allowing the blood to drip into a depression of

a porcelain spot-plate, while pressure was exerted on the body. Ether anaesthesia of short duration, shown by LUDWIG (1951) to be superior to the use of anticoagulants, was found effective in preventing gelation of the blood. It was possible to obtain 0.1 cc. of blood from about 35 larvae. The blood was collected, pooled and analyses were made on the pooled blood for reducing substances, protein and non-protein nitrogen. The reducing value of the blood was estimated by the method of HAGEDORN and JENSEN (HAWK, OSER and SUMMERSON, 1947, p. 528). Usually 0.015 cc. blood was used for each determination. KUWANA (1937) termed the re-reducing value estimated by this method the "total reducing value". Protein and non-protein nitrogen in the blood were estimated by the method described by LUDWIG (1951). Again 0.015 cc. blood was used for each estimation. The value for total nitrogen was obtained by adding the protein and non-protein fractions. The amount of protein was calculated by multiplying the figure for protein nitrogen by the protein conversion factor 6.25.

The results of blood analyses are presented in mg. substance per cc. blood. The average values for these substances in each age were calculated by dividing the total sum of the values obtained in the multiple estimations by the number of determinations.

The respiratory quotient of the larvae was estimated by the micro-respiratory apparatus designed by KRÜGER (1937), at 31.5°C. The apparatus is designed to measure at the same time very small amounts of oxygen consumed and carbon dioxide produced by the same animal. Usually 10 animals, previously weighed, were used in each experiment. The results are given in c.mm. oxygen consumed or carbon dioxide produced per mg. larvae in 30 minutes at 31.5°C.

In the determination of the losses of food reserves taking place during the process of pupation, both types of pupae (emerging from active and from resting larvae) were collected during the first five days following pupation. The resting larvae which pupated were from the same big lot, from which samples had been taken for the analyses described before. The pupae were analysed for fresh weight, dry weight, water content, ash, glycogen, fat, total nitrogen, protein and non-protein nitrogen by the same methods of analysis used in case of the diapausing larvae. The results are presented in the same manner as before.

III. RESULTS

(A) Analyses of larvae in the active and in the diapause stages

(1) *Changes in the composition of the body*

The results of the determination of the fresh weight, dry weight, water content and ash content of active and diapausing larvae are given in Table I from which it can be seen that the average fresh weight per larvae decreased rapidly as it entered diapause, and rose again slightly towards pupation. The same fluctuations were observed in the water content per larva and in the water content expressed in per

TABLE I

Fresh weight (FW), dry weight (DW), water content and ash content of active and resting larvae of the pink bollworm (est.=estimations; Av.=average)

Larva	No. of larvae est.	Fresh weight			Dry weight			Water content			No. of larvae est.	Ash content			
		mg./larva		No. of larvae est.	mg./larva	% of larvae est.	mg./larva	% of FW.	mg./larva	% of Av. DW.					
		Av.	Range									Av.	Range	Av.	Range
Active.....	4	28.75	27.89-30.11		9.47	8.90-10.16		19.78	18.99-19.95	67.1	2	10	0.25	0.21-2.29	2.64
Resting:															
10 days	2	25.43	25.02-25.84		9.25	9.04-9.46		16.19	15.56-16.81	63.5	2	5	0.24	0.22-0.26	2.59
45 days	3	21.79	21.21-22.56		8.31	8.01-8.61		13.48	13.00-14.24	61.8	2	5	0.24	0.22-0.26	2.89
80 days	2	22.88	22-12-23.46		7.8	7.52-8.09		15.08	14.60-15.55	65.7	2	5	0.22	0.21-0.24	2.82

cent of the fresh weight. At the end of ten days of rest, the loss of water amounted to 16% of the average amount of water present in the active larva and this was followed by another loss of 14% at 45 days of rest. Near pupation, the amount of water per larva was slightly raised, while the percentage had reached a level close to that present in the active stage. The dry weight, on the other hand, decreased to a smaller extent and in a gradual manner, until the resting larvae approached pupation. The total loss of dry weight at the end of 80 days of rest is 17.6% of the figure for the active stage.

Almost negligible changes were observed in the amounts of ash per larva during the whole period of rest, or in the ash content expressed in per cent of the dry weight.

The results of the determination of glycogen are summarised in Table II. A loss of 34.5% of the amount present in the active larvae occurred at the end of the first ten days of rest; this value rose to 53.3% in resting larvae 45 days old. No further loss, but rather a gain took place thereafter toward the end of diapause, where the glycogen content in per cent of the dry weight was raised to a level similar to that present in the initial (active) stage.

In Table II are also given the figures for the fat content of the active and resting larvae. In general, the fat content of the larvae was high at all stages (roughly half the dry weight). The fat content (both in per cent of the dry weight and in

TABLE II

Glycogen and fat contents of active and resting larvae of the pink bollworm

(a) Glycogen

Larvae	Number of est.	Number of larvae/est.	mg./larva		Percentage of Av. DW.
			Average	Range	
Active	3	15-25	0.249	0.243-0.259	2.63
Resting :					
10 days	2	20	0.163	0.153-0.172	1.75
45 days	2	15	0.116	0.111-0.121	1.4
80 days	2	15	0.207	0.202-0.212	2.65

(b) Fat

Active	4	10-15	4.69	4.53-4.82	49.5
Resting :					
10 days	3	15	5.12	4.9-5.35	55.3
45 days	3	15	4.41	4.1-4.54	53
80 days	2	15	3.96	3.76-4.15	50.7

TABLE III. — Total nitrogen, non-protein nitrogen and protein nitrogen in active and resting larvae of the pink bollworm

Larvae	Number of est.	Number of larvae/est.	Total nitrogen				Number of est.	Number of larvae/est.	Non-protein nitrogen				Protein *		
			mg./larva		% of Av.				mg./larva		% of Av.		mg./larva	Range	% of Av.
			Av.	Range	Av.	Range			Av.	Range					
Active	2	3	0.7553	0.7379-0.7727	7.97	3	10	0.11	0.1091-0.1104	1.16	0.6453	4.0331	42.5		
Resting:															
10 days	4	3	0.6651	0.6320-0.6779	7.20	3	13	0.09	0.0942-0.0985	1.04	0.5691	3.5569	38.4		
45 days	2	5	0.6074	0.5639-0.6509	7.32	2	11	0.0686	0.0686-0.0686	0.826	0.5388	3.3677	40.6		
80 days	2	3	0.6110	0.6001-0.6200	7.83	2	11	0.0776	0.0776-0.0776	0.994	0.5334	3.3337	42.7		

* The figures of protein content were calculated from the average values of total N and non-protein N.

* The figures of protein content were calculated from the average values of total N and non-protein N.

TABLE IV. — Totals of the average values found for glycogen (G), fat (F), protein (P), non-protein nitrogen (N.P) and ash (A) in active and resting larvae of the pink bollworm (data from Tables I, II and III)

Item	Active larvae		Resting larvae						Change between active and resting larvae 80 days old	
			10 days		45 days		80 days			
	mg./larva	% of av. DW.	mg./larva	% of av. DW.	mg./larva	% of av. DW.	mg./larva	% of av. DW.	mg./larva	% of av. DW.
G + F + P + N.P ÷ A	9.3321	98.43	9.1759	99.08	8.2023	98.72	7.7983	99.86	1.5338	92
Av. DW.	9.47	100	9.2500	100	8.3100	100	7.8000	10	1.6700	100
Unaccounted for	0.1379	1.57	0.0741	0.9200	0.1077	1.2800	0.0017	0.1400	0.1362	8

amount per larva) of the newly resting larvae (10 days old) was higher than that present in the active stage. A gradual decrease took place thereafter: when the larvae approached pupation (80 days old) the percentage was again at a level similar to that present in the active stage (50.7%).

It had been shown (EL-SAYED and RUSTOM, 1960) that resting larvae kept at 13°C never pupate and die after very long periods. This is true whatever the time of introducing the larvae to this temperature. It was considered interesting to measure the water and fat contents of such larvae. Samples of larvae 272 days old were taken from a stock kept under these conditions and analysed. The results show that the water content of such larvae (65.6%) was similar to that present in the resting larvae 80 days old (kept at room conditions), however the average values of the fresh weight (19.59 mg/larva), dry weight (6.74 mg/larva) and water (12.85 mg/larva) were much less than those found for larvae after 80 days of rest (Table I). On the other hand the fat content was low both in amount (2.64 mg/larva) and in per cent of the dry weight (39.1%). At this age (272 days old) 48.5% of the amount of fat present in the newly resting larvae (10 days old) had been lost.

The results on the distribution of nitrogen in active larvae and in resting larvae at different ages are given in Table III. The total nitrogen at the end of 45 days of rest showed a considerable deficit, amounting to 19.6% of the quantity present in the active stage. This loss took place in two successive steps; 11.9% were lost at end of the first ten days of rest and 7.7% during the interval 10 to 45 days. No appreciable changes were observed thereafter. These changes are not as clearly demonstrated when the total nitrogen is expressed in per cent of the dry weight. This is due to the decrease in dry weight in this interval, which decrease is not only due to decrease in nitrogenous substances, but mainly due to a decrease in fat and glycogen.

Non-protein nitrogen decreased steadily towards the middle of the diapause period, both in amount per larva and in per cent of the dry weight. This was followed by a slight increase towards pupation, which is however too small to be given any significance.

Values for the protein nitrogen and for the calculated protein number show marked changes, *i.e.* a considerable loss at the beginning of diapause (11.8% of the amount present in the active stage), followed by another drop (4.7%) at the end of 45 days of rest, while only small changes were observed from that age onwards till the larvae approached pupation. On the other hand, the figures for the protein content in per cent of the dry weight were lower at the early diapause stage, increasing steadily till near pupation where it approximated the percentage present in the active stage; a picture which is different from that obtained when analysing the results on the basis of the amounts in mg. per larva. The higher percentage towards the end of the diapause shows that more of the solid matter is formed by protein, less by fat and glycogen than at the initial stage of diapause.

In Table IV are presented the totals of the average values of the glycogen,

fat, non-protein nitrogen, protein number and ash for the resting larvae at different ages, as well as for the active larvae. From this Table it is seen that, at all ages, there are always certain fractions which were not accounted for in the analyses. These vary between about 0.002 to 0.14 mg. per larva or between 0.14 and 1.57% of the average dry weight and must be mostly due to errors in the analyses. Moreover, the non-protein substances would account for a bigger fraction of the dry weight than the figures given here as non-protein nitrogen.

Table V summarises the changes that took place in the major components of the body between the active larvae and each of the successive resting ages on the one hand and between each resting age and the previous age on the other. From this Table it appears that at the beginning of the resting stage glycogen and protein were lost, while fat was building up. In the period between 10-45 days of rest a small amount of glycogen and a fair amounts of fat and protein had disappeared, however the major loss was due to fat. During the last period in the resting stage (between 45-80 days) fat was the main reserve substance utilised, negligible amount of protein was lost while glycogen was slightly building up.

(2) Changes in the respiratory quotient

The result of a few experiments on the oxygen consumption, carbon dioxide production and the respiratory quotient of both active and resting larvae (64 days old only, because it was not possible to continue these determinations of the respiration as the apparatus was no longer available) at 31.5°C, are given in Table VI from which it is clear that the values of the oxygen consumption and the carbon

TABLE VI

Oxygen consumption and carbon dioxide production in active larvae and in 64 days old resting larvae (results expressed in c.mm. oxygen or carbon dioxide per mg. larva in 30 minutes at 31.5°C)

Larvae	Number of readings	Oxygen consumed		Carbon dioxide produced		R.Q.
		Average	Range	Average	Range	
Active	2	0.722	0.681	0.6735	0.631	0.932
		±	—	±	—	±
		0.041	0.763	0.042	0.716	0.006
Resting: 64 day- old	6	0.425	0.004	0.318	0.301	0.747
		±	—	±	—	±
		0.012	0.482	0.012	0.354	0.007

dioxide production in diapausing larvae at that age were considerably lower than those in the active larvae. A decrease of about 41% in the oxygen uptake and of 53% in the carbon dioxide output were observed. The respiratory quotient in the

active stage (0.932) indicates the oxidation of carbohydrates while that of the resting larvae 64 days old (0.747) indicates the oxidation of fat.

(3) *Changes in the blood*

Results of the determinations of the composition of the blood of both active and resting larvae are presented in Tables VII and VIII. From Table VII it is seen that the amount of protein increased considerably in the newly resting larvae. Later in the resting stage protein dropped very sharply. The amount of non-protein nitrogen rose steadily during the first 10 days of diapause and reached its maximum

TABLE VII

Distribution of nitrogen in the blood of active and resting larvae of the pink bollworm
(results are given in mg. per cc. blood)

Larvae	Number of est.	Protein			Non-protein N		Total N*
		Protein N		Protein	Average	Range	
		Average	Range				
Active	4	19.34	18.85 — 20.4	121	5.05	4.82 — 5.51	24.39
Resting: 10 days ..	3	25.23	24.20 — 26.10	158	10.52	8.17 — 12.90	35.75
45 days ..	7	1.80	1.49 — 2.24	11.25	26.8	20.9 — 30.1	28.6
80 days ..	4	2.73	2.70 — 2.75	17.05	8.48	6.87 — 11.1	11.21

* Values of total N were calculated from the average values of the protein and non-protein N.

value in the larvae after 45 days of rest. This was followed by a rapid fall towards pupation. The figures for the total nitrogen show a similar fluctuation to that of the protein nitrogen content, but less pronounced due to the rise in non-protein nitrogen.

The values obtained for the concentration of the reducing components in the blood are given in Table VIII, from which it is seen that a sharp drop of about

40% (of the amount present in the active stage) occurred when the larvae first entered diapause. The level was retained at approximately the same low value throughout the remaining period of diapause.

TABLE VIII

*Reducing value of the blood of active and resting larvae of the pink bollworm
(results are given in mg. glucose per cc. blood)*

Larvae	Number of est.	cc. blood/est.	Average	Range
Active	3	0.015	3.45	3.3-3.53
Resting:				
10 days	6	0.015	2.08	1.7-2.60
45 days	6	0.015	2.37	1.6-3.00
80 days	6	0.015	2.3	1.8-2.80

(B) Analyses of pupae

Results of the composition of the pupae emerging from both active and resting larvae are given in Tables IX, X and XI. The figures in these Tables, when compared with those obtained from active larvae and resting larvae 80 days old (Tables I, II and III), show the following:

Table IX shows that about a quarter of the fresh weight of both types of larvae had been lost in the process of pupation (and the few days thereafter until the time of analyses). This is mainly due to the corresponding loss in the water content, being 25.5% in case of pupae emerging from active larvae and 24.5% in those emerging from resting larvae. The average figures for the fresh weight and for the water content in mg per larva are higher in pupae of active larvae than in pupae of resting larvae as is the case for the larvae themselves. However, the figures for the water content in per cent of the fresh weight are nearly the same for both types of pupae and almost identical with those found for the larvae (Table I) from which they are formed. As to the average dry weight, it seems that the process of pupation of the active larvae was accompanied by a comparatively bigger loss in solids than in the case of pupation of the resting larvae; the losses being 26.7 and 17%, respectively. However, the average values of the dry weight are similar.

In both types of pupae, the average amounts of ash in mg per larvae are similar to each other, but lower than the corresponding amounts in larvae. The values for ash, in per cent of the dry weight, are close to those found in the prepupal stages.

The amount of glycogen per pupa of both lots (Table X) is much lower than that of the respective prepupal stages, the loss being 30.9% in case of pupae

TABLE IX. — *Fresh weight, dry weight, water content and ash content of pupae of the pink bollworm*

Pupae	Number of est.	Fresh weight		Dry weight		Water content			Ash content		
		mg./pupa		mg./pupa		mg./pupa	of av. FW.		mg./pupa	of av. DW.	
		Av.	Range	Av.	Range		Av.	Range		Av.	Range
From active larvae ..	3 10	21.3	20.4-22.39	6.94	6.65-7.34	14.37	13.85-15.05	67.47	2	5	0.19 0.18-0.21
From resting larvae ..	4 10	17.84	16.95-18.73	6.47	6.33-6.71	11.38	10.63-12.33	63.78	2	5	0.195 0.18-0.20

TABLE X. — *Glycogen and fat content of pupae of the pink bollworm*

(a) Glycogen

Pupae	Number of est.	Number of pupae/est.	mg./pupa		% of av. DW.
			Average	Range	
From active larvae	2	25	0.172	0.168-0.175	2.47
From resting larvae	2	15	0.154	0.149-0.159	2.38

(b) Fat

Pupae	Number of est.	Number of pupae/est.	mg./pupa		% of av. DW.	
			Average	Range		
From active larvae	2	15	3.05	2.5-3.60	43.94	
From resting larvae	2	15	2.75	2.53-2.96	42.50	

TABLE XI
Total nitrogen, non-protein nitrogen and protein nitrogen in pupae of the pink bollworm

P u p a e	Number of est.	Number of pupae est.	Total N			Number of est.	Number of pupae est.	Non-protein N			Protein *			
			mg./pupa	% of av. DW	Av.			Range	mg./pupa	% of av. DW	Av.	Range	mg/pupa	% DW
From active larvae	3	3	0.6418	0.6246-0.6601	9.25	3	10	0.1607	0.1574-0.1624	2.32	0.4811	3.0069	43.35	
From resting larvae	3	3	0.5546	0.5366-0.5813	8.55	3	5	0.0947	0.0939-0.0964	1.46	0.4599	2.8744	44.46	

* The figures of protein content were calculated from the average values of total N and non-protein N.

TABLE XII

Totals of the average values found for glycogen (G), fat (F), non-protein nitrogen (N.P.), protein (P) and ash (A) in pupae of the pink bollworm


(data from Tables IX and XI)

I t e m	Pupae from active larvae		Pupae from resting larvae	
	mg./pupa	Percentage of av. DW.	mg./pupa	Percentage of av. DW.
G+ F+ N.P+ P+ A ..	6.5796	94.82	6.0681	93.81
Av. DW	6.9400	100.00	6.4700	100.00
Unaccounted for	0.3604	5.18	0.4019	6.19

TABLE XIII

Changes in dry weight, glycogen, fat and protein found during pupation of active and resting larvae

(+ve=gain; -ve=loss; calculated from the data in Tables I, II, III, IX, X and XI).

 change in	Active larvae to pupae		Loss in % of loss of G + F + P	Resting larvae to pupae		Loss in % of loss of G + F + P
	mg/larvae	in % of amount in A		mg/larvae	in % of amount in R80	
Glycogen	-0.077	-30.9	2.8	-0.053	-25.6	3.1
Fat.....	-1.64	-35	59.7	-1.21	-30.5	70.2
Protein	-1.032	-25.6	37.5	-0.46	-13.8	26.7
G + F + P	-2.749	-30.7	100	-1.723	-23	100
Non-protein N	+ 0.05	—	—	+ 0.017	—	—
Ash	-0.06	—	—	-0.025	—	—
Total	-2.752	—	—	-1.728	—	—
Unaccounted for	+ 0.22	—	—	+ 0.398	—	—
Original DW	-2.53	-26.7	—	-1.33	-17	—
Fresh weight	-7.45	-25.9	—	-5.04	-22	—
Water	-4.91	-25.5	—	-3.7	-24.5	—

of active larvae and 25.6% in case of pupae of resting larvae. However, the glycogen content in per cent of the dry weight is close to each other in both pupae and also close to that of each of the corresponding larval stage.

Comparatively bigger changes were observed for the fat content on pupation (Table X); in both groups the amount per larva and the percentage of the dry weight are lower than in the corresponding larvae. Pupae emerging from active larvae lost 35% fat on the average in the process of pupation, while those resulting from the resting larvae lost 30.5%.

The amount of protein (Table XI) is lower in pupae of both groups compared with that in the respective prepupal stage; the losses being 25.6 and 13.8% in pupae of active and resting larvae respectively. However, the percentual protein content was almost unchanged, showing a small increase in both types of pupae. On the other hand non-protein nitrogen had much increased both in amount per larva and in per cent of the average dry weight.

Table XII summarises the totals of the average values found for the glycogen, free fat, non-protein nitrogen, protein and ash for both types of pupae. In this table are also given the figures for the average dry weight and by subtraction, the figures for the "unaccounted for" fractions were obtained. The small discrepancies between total dry weight and total substances found, must again be due to errors in the analyses. The figures for this fraction (which vary between 0.36 and 0.4 mg. per pupa) should be less, since the non-protein nitrogen must have been present as, e.g., amino acids or nitrogenous excretory matter.

Table XIII shows the changes in the major components of the body during pupation of both the active larvae and resting larvae. It can be seen that a loss of fat, protein and glycogen occurred in both cases of pupation, whereas there is an increase in non-protein nitrogen. The ash content can be seen to decrease only little and equally in the two types of pupae.

IV. DISCUSSION

The observations on the fall in the water content in the larvae of the pink bollworm at the onset of diapause, which fall continued during the greater part of the diapause, are in accordance with the findings of SQUIRE (1940) and FIFE (1949) on this insect. SQUIRE explained the difference in the water content between the active and resting stages as being due to a difference in composition of the bolls ingested by the larvae at different times in the cotton season. According to this author the lower percentage of the water content of the food would cause a reduction in the water content of the larvae and this in turn would cause the larvae to pass into the resting stage. FIFE's explanation of his findings of lower water content is similar to the one of SQUIRE. However, the present results indicate that this lowering in the water content of the larvae is an effect of acquiring a new phase, rather than a cause. On the other hand, it is unlikely that the lowered water content in

the present case is due merely to starvation, since BUXTON (1930) reported that larvae of *Tenebrio* after 4 weeks of starvation at R.H. 0-60% had maintained a constant percentage of water; Buxton attributed this water balance to the retaining of water produced in metabolism. Similar results were obtained by FRAENKEL and BLEWETT (1944) for starving larvae of *Tribolium*, *Ephestia* and *Dermestes*.

The observed fall in water content in the initial and medium stages of diapause and the observed rise at the termination of the resting period are similar to the changes in water content at the onset and at the end of hibernation, observed by TOWER (1906) in *Leptinotarsa*, by BODINE (1923) in grasshopper, etc. Some of these results had led TOWNSEND (1926) to state that the beginning of hibernation in cold blooded animals in general is marked by a reduction in water content and the breaking up of this stage is marked by an increase of this water.

A considerable and prolonged fall and an ultimate slight rise were observed in the average fresh weight of the larvae during diapause, as had also been found by GOUGH (1919) for this insect. These changes in the fresh weight could be shown to be mainly due to changes in the amount of water, the changes in the dry weight being only small in comparison.

Glycogen appears to be consumed for a great part during the initial stages of diapause of the pink bollworm. This observation is in broad agreement with the generally accepted theory of WIGGLESWORTH (1953), that carbohydrates are one of the main sources of energy during the initial stages of starvation. However, the loss of glycogen continued to a considerable degree even later in the diapause. The bigger bulk, being 34.5% of the original amount present in the active stage, was consumed in the period till the end of the first 10 days of rest and 18.8% were lost during the next 35 days of rest. This means that consumption continued during nearly half the average duration of the resting stage. A similar result was obtained by NEWTON (1954) in starving diapausing *Popillia* larvae. NEWTON, however, did not complete his analyses to cover the whole period of diapause in *Popillia* larvae, which according to LUDWIG (1953) lasts for about 50 days. In addition he did not give a full series of analyses on one and the same type of larvae, but he analysed starving diapausing larvae for glycogen and "post-diapause" larvae, which are kept also in a state of starvation, for nitrogen and fat. These two stages are not comparable, as they may differ in their reaction to starvation, as is clear from the fact that "post-diapause" larvae can withstand starvation for at most 30 days after which they die. The results achieved by MELLANBY (1932) on starving *Tenebrio* larvae and those by LUDWIG (1950) on starving nymphs of *Chortophaga* closely follow the theory of WIGGLESWORTH mentioned above. On the other hand WIGGLESWORTH himself (1942) working on starved *Aedes* larvae reported a gradual loss of glycogen during the whole period of inanition in this insect.

The apparent increase in the amount of glycogen towards the end of the diapause period found in the present work was unexpected; however the value of glycogen in mg. per larva had not yet reached the original level present in the active

stage. None of the previously mentioned authors had recorded any rise in amount of glycogen towards the end of diapause or starvation periods.

The utilisation of fat differs from that of glycogen during diapause. It seems that there is a sort of storing of this food reserve at the onset of the resting stage; 9.2% more of the amount present in the active stage are present in the ten days old resting larvae. It may be that in the very last days of the active stage the fat content had reached even higher values than those recorded here for the active larvae. Daily analyses would have to be made to ascertain this point. This building up of fat is most likely to have taken place at the expense of protein, which decreased considerably during the initial period of the resting stage. A conversion of protein to fat is also known to occur in other insects; according to BUCK (1953, pp. 228 and 230) such conversion has been demonstrated in fly larvae and silkworms, as well as in some adult insects. Moreover, ROUBAUD (1922) found that in adult *Culex* during the first month of hibernation the fat increased at the expense of some larval muscles, still present in the adult.

The increase in the fat content was followed in the later stages of diapause by a gradual loss, both in amount and in per cent of the dry weight, till the larvae approached pupation. This loss in fat, being 22.6% of the amount present in the newly resting larvae was, however, not very extensive. The utilisation of fat in the period between 10-45 days of rest went parallel with that of glycogen, while later in the period between 45 and 80 days of rest, fat seemed to be the major food reserve being lost. This is proved by the results obtained for the R.Q. on 64 days old resting larvae, where the R.Q. had dropped to 0.747 indicating fat oxidation or mobilisation. SQUIRE (1940) had recorded a high level (42.4%) of fat content in diapausing larvae of the pink bollworm 6 months old, while his figure for normal larvae was 27.6%. The results obtained here show that the biggest difference found in the fat content between active and resting larvae (9.2%) is smaller than that recorded by SQUIRE. An increase in the percentage of fat at the onset of diapause was also registered by WALOFF (1949) in diapausing larvae of *Ephestia*, and during diapause by SACHAROV (1930) and KOZHANTSHIKOV (1935) in larvae of *Eurpactis chrysorrhoea* respectively *Pyrausta nubilalis*. During starvation a parallel consumption of fat and glycogen had been found to occur in *Aedes* larvae (WIGGLESWORTH, 1942) and in post-diapausing larvae of *Popillia* (NEWTON, 1954). The conclusions arrived at by LUDWIG (1950), that fat is the chief reserve substance utilised after glycogen is exhausted during starvation of *Chortophaga* nymphs, is in agreement with our results, though Ludwig had recorded a consumption of fat, though small, during the initial stages of starvation in this insect as well. In general fat utilisation during periods of rest was recorded by many other authors as HELLER (1926) for starved adults of *Deilephila*, MELLANBY (1932) for starved larvae of *Tenebrio*, BUXTON (1935) for hibernating adults of *Culex* and LAFON (1941) for starved adults of *Phormia*. On the other hand only small changes of the fat content during most of

diapause period have also been recorded notably by TIMON-DAVID (1928) in diapausing larvae of *Pyrausta* and by BUSNEL and DRILHON (1937) in hibernating adults of *Leptinotarsa*; it was only at the end of this period that the fat content was found to fall considerably.

The results of the fat content of resting larvae kept at 13°C. for 272 days indicate that the larvae under these conditions utilise considerable amounts of fat, even if the fat content reaches a much lower level (in amount and in per cent of the dry weight) than that arrived at by the larvae at the end of the resting stage under the normal conditions of the laboratory. This is due to the unfavourable temperature which seems to be below the threshold of development: the larvae kept at this low temperature can live on for very long periods (up to 411 days) but all of them ultimately die without metamorphosing, if kept at the low temperature.

The observed loss in amount of the total nitrogen was found to be mainly due to a loss in the protein nitrogen. This was especially evident at the beginning of diapause, till ten days of rest where about 12% (of the amount present in the active stage) were lost, both for the total nitrogen and protein nitrogen. The decrease in protein took place at the same time when fat was building up, thus it seems plausible to postulate that synthesis of the latter food reserve had taken place at the expense of protein. Glycogen, from which a considerable amount was lost at that time (as seen from Table II) may share also in fat accumulation, but to a much lesser extent than protein, since the amount in mg. of used up glycogen was comparatively small. A further but less extensive loss in protein occurred in the period between 10-45 days of rest, namely 4.7% and only negligible changes took place afterwards. This means that protein can serve also as a source of energy especially near the middle of the diapause period.

If fat was formed at the expense of protein an increase in amount of the non-protein nitrogen fraction might have been expected, yet such was not the case in the diapausing pink bollworm. The amount of non-protein N was observed to decrease continuously. It may be that small amounts of excreta defecated around the borders of cocoons of the resting larvae are responsible for this loss, but it was found impossible to collect these. On the other hand, a rise in the amounts of non protein nitrogen in the blood was observed parallel with the decrease in amount of body protein. This finding supports the suggestion of a transformation of protein to fat, and may also point to the presence of excretory nitrogenous products in the blood. However, the exact nature of the nitrogenous compounds responsible for the non-protein nitrogen fraction of either whole larvae or of blood is not known. LUDWIG and ROTHSTEIN (1952) who determined the non-protein nitrogen in the embryo of the Japanese beetle, suggested that this fraction might contain amino acids, some peptides, glucosamine and soluble waste products (uric acid, allantoin, urea, ammonia, etc.).

The observed loss in total nitrogen during the diapause stage has its parallel in the loss of nitrogen during starvation of some insect larvae and adults, reported

frequently (HELLER, 1926, for adult *Deilephila*: MELLANBY, 1932, for *Tenebrio* larvae; LATON, 1941, for adult *Phormia*: WIGGLESWORTH, 1942, for *Culex* larvae and NEWTON, 1954, for *Popillia* larvae). On the other hand utilization of protein has not been observed in starving adults of the honey-bee (KELLER-KITZINGER, 1935) nor in the nymphs of *Chortophaga* (LUDWIG, 1950) and in diapausing *Popillia* (NEWTON, 1954).

As to the changes in composition of the blood of the pink bollworm it was demonstrated (Table VII) that protein rose from a normal concentration of 121 to 158 mg. per cc. blood at the onset of diapause. This increase took place simultaneous with the big breakdown of body protein. It was followed by a rapid decline in protein content of the blood so that near the end of the diapause period almost all protein has disappeared from the blood. A similar consumption of blood protein had also been observed in the starved larvae of *Deilephila* (HELLER and MOKLOVSKA, 1930) but not in the starved or diapausing larvae of *Popillia* (LUDWIG and WUGMEISTER, 1953; LUDWIG, 1954).

Non-protein nitrogen in the blood showed a continuous increase from the time the larvae entered diapause till about half way the resting period, where the concentration reached about five times that present in the active stage. This was followed by a decline in the concentration towards the end of diapause. These fluctuations will be better explained when dealing with the reducing value of the blood. Generally the ratio of non-protein nitrogen to total nitrogen in insect blood is about 1:2 (WIGGLESWORTH, 1953). This proportion is not shown by the present data on the composition of the blood in the pink-bollworm. The ratio decreased from about 1:5 in the active stage to 1:3.5 in the newly resting larva, to 1:1 in larvae near the middle of the diapause after which it rose to 1:1.3 near pupation.

The blood of insects, in general, has a high content of reducing substances. The bulk of these substances is not sugar, the fermentable reducing substance (the true blood sugar) forms only about a quarter of these substances (WIGGLESWORTH, 1953). The nature of the other reducing components is not known; however it was suggested by Wigglesworth that they include phenolic substances which play a part in the hardening and darkening of the cuticle. LUDWIG and WUGMEISTER (1953) in estimating the reducing value of the blood of starved *Popillia* larvae observed a certain amount of increase at the end of the starvation period. They stated that such results would give no information regarding the possible use of blood glucose, since other substances with reducing properties may appear in the blood as glucose is being oxidised. Amongst the substances with reducing properties, they listed glucosamine, uric acid and allantoin, which would also be included in the determinations of non-protein nitrogen. The results of LUDWIG and WUGMEISTER were confirmed and extended by LUDWIG and CULLEN (1956) for the same insect. The present results with regard to the reducing value of the blood showed that consumption of blood glucose took place only at the initial stages of diapause and no further change was observed till near pupation: this is again in accordance with WIGGLESWORTH'S

theory (1953) about carbohydrate utilisation during the initial stages of inanition in animals. On the other hand, the appearance in the blood of some of the substances listed by LUDWIG and WUGMEISTER might explain the successive rise in the amounts of non-protein nitrogen in the blood. The arrest in decrease of the figures for reducing substances at 10 days and the small increase in the later periods of diapause suggest that glucose may be further lost from the blood, while other reducing nitrogenous substances are added.

The data in the present work on the changes in composition of the body during pupation were obtained from two groups of larvae, one formed by active larvae which pupated without having gone through a period of diapause and second one formed by larvae which pupated after the normal time of diapause. From the results given above (Table IX), it is seen that the fresh weight, after pupation in both groups of larvae, had decreased considerably (to about 75% of the larval weight) and evidence was brought forward which shows that this loss in fresh weight was due for the major part to loss of water during pupation and for the minor part to loss of dry weight. In part this loss of dry weight may be due to the casting of the larval skin. A similar but bigger loss in fresh weight and in water had been found by several authors (*vide* BUCK, 1953, p. 209) during pupation of larvae of *Bombyx mori*. The recorded losses of fresh weight and water were interpreted by BUCK as being due to the loss of material purged from the gut and of wet silk secreted. Buck expressed doubt whether a disproportionate water loss occurred, especially that the percentage body water decreased very gradually between the start of the fifth larval instar and the first day of pupation. That no disproportionate loss of water alone occurred was also found in the present work: the percentual water content remained constant during pupation from active larvae and decreased only slightly during pupation from resting larvae. The lesser loss of fresh weight observed here than that found in *Bombyx mori* may be due to the fact that no cocoon is spun as by the silk worm. The observed loss in dry weight is similar to that found by HELLER (1926) on pupation of *Deilephila*, which loses about one quarter of the dry weight during pupation, whereas *Bombyx mori* loses half its dry weight.

The loss in dry weight per larva was different in the two groups, the active larvae losing on pupation about twice as much in amount as the resting larvae during this process, while the loss in dry weight in per cent of the original amount of the larvae, although less pronounced, was also slightly more in the first group. The pupae resulting from the resting larvae were smaller (less fresh weight and dry weight) than those from the active larvae, in accordance with the lesser weight of the precursor larvae. The loss in dry weight during pupation was found to be due mainly to a loss in fat and protein, and hardly to a loss in glycogen, as is known to occur in pupation in some other insects, *e.g.* the bee (*vide* WIGGLESWORTH, 1953, p. 394) and in the silkworm (*vide* NEEDHAM, 1950, p. 471). As can be seen from the summary of the results in Table XIII, the loss in fat during pupation of active larvae accounted for 59.7% of the total loss of glycogen, fat and protein together, whereas

the loss in fat during pupation of resting larvae was 70.2% of this total. The loss in protein amounted to 37.5 and 26.7% in the two groups, whereas the glycogen was only responsible for about 3% of the total loss in these three substances in both cases. There seems to be therefore only little difference in the metabolic changes taking place during pupation from active and from resting larvae, the proportion of amounts being used up being rather similar. However, the actual amounts of fat and protein (in mg. per larva or pupa) lost were lower in pupation from resting larvae, probably due to the lower absolute amounts of these substances in the precursor larvae. The amount of protein lost from active larvae during pupation is more than double the amount lost from resting larvae. This bigger loss in protein was found to be accompanied by a bigger gain in non-protein nitrogen. The gain in non-protein nitrogen in each case may be attributed to an accumulation of waste products of nitrogenous nature. A similar increase in products of protein breakdown and a decrease in protein had been found during the first stages of pupation, e.g. in *Lucilia sericata* by EVANS (1939).

The figures for the loss of protein and fat in percent of the original amounts of each of these substances present in the larvae, show that during pupation of active larvae the percentual loss of protein was almost double that of resting larvae, while the percentual loss of fat was only little higher in the first case. The results of all these changes is that the final concentration of fat (in per cent of dry weight) was slightly less in the pupae of resting larvae than in those of active ones, whereas the resting larvae themselves had a higher fat content than the active larvae. The changes in protein content during pupation in both groups were too small for any conclusion to be drawn.

It can be concluded that during pupation of the active larvae bigger amounts of protein and fat were lost than during pupation of resting larvae, the losses in glycogen being equally small in both groups.

V. SUMMARY AND CONCLUSIONS

(1) The composition of larvae in the diapause stage of different ages was determined and compared with the composition of active larvae just before diapause. In addition pupae emerging from active larvae as well as those from resting larvae were analysed.

(2) The average fresh weight per larva decreased rapidly as it entered diapause and rose again slightly towards pupation. This was found to be mainly due to corresponding changes in the water content. The percentage of the latter rose near pupation to a level close to that in the active stage. The larvae lost 17.6% of its dry weight during the whole period of diapause and this loss took place gradually. Negligible changes in the ash content were observed during the resting stage.

(3) As the diapause proceeded, the following changes in the major organic constituents took place:

- (a) In the period between the active stage and the stage after ten days of rest: varying amounts of glycogen and protein were lost, while fat was gained.
- (b) In the period between 10 and 45 days of rest: varying amounts of glycogen, fat and protein were lost.
- (c) In the period between 45 and 80 days of rest: some gain in glycogen occurred, only a small amount of protein was lost and fat was the major reserve substance being utilised. This was supported by the results of measurements of the R.Q. in active larvae and in 64 days old resting larvae.

(4) Towards the end of diapause, the amounts of glycogen, fat and protein, in per cent of the dry weight, reach a similar level to that present in the active larvae. However, this is not valid for the absolute amounts of these substances.

(5) The composition of the blood of the resting larvae has been found to vary greatly from that of the active larvae.

(6) During pupation of the active larvae relatively more protein and fat are lost than during pupation of the resting larvae; equally small amounts of glycogen are lost from both types of larvae during pupation. However, when expressed in percentage of the dry weight, the values found for most of the components of the body of both types of pupae are close to each other and to the precursor larvae.

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ANATOMICAL STUDIES ON *ACRIDA PELLUCIDA* KLUG

[*Orthoptera: Acrididae*]

(with 18 Text-Figures)

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INTRODUCTION

In a previous work the present authors (HAFEZ and IBRAHIM, 1958 and 1959) gave detailed accounts on the biology, ecology and histology of the alimentary canal of the grasshopper *Acrida pellucida* Klug. This is another paper on the same species which deals with the anatomy of the internal organs.

The review of literature reveals that the internal anatomy of a number of Acridid species has been thoroughly studied, e.g. *Dociostaurus maroccanus* (JANNONE, 1940), *Leptysma marginicollis* and *Opshomala vitreipennis* (HODGE, 1943), *Locusta migratoria* (ALBRECHT, 1943) and *Nomadacris septemfasciata* (ALBRECHT, 1956). Other authors described the anatomy of certain systems, e.g. the digestive system (TIETZ, 1923; HODGE, 1936, 1939, 1940; CHAUVIN, 1938), the reproductive system (e.g. LAIRD, 1943), the respiratory system (e.g. VINAL, 1919) and the nervous system (e.g. NESBITT, 1941; BICKLEY, 1942).

THE ALIMENTARY CANAL

As in most Acridids, the alimentary system of adult *Acrida* (Fig. 1) consists of a nearly straight and cylindrical tube. It extends through the long axis of the body from the mouth to the anus, with three sets of diverticula: the salivary glands, the gastric caeca and the Malpighian tubes. The relative position of the different regions of the tract in the body cavity is subject to slight variation. This is because

of the loose attachment in the body cavity, the elasticity of its wall and the differing degree of distention of its various parts.

The stomodaeum

The stomodaeum extends from the mouth upward in the head, with a slight curving anteriorly. It passes between the anterior tentorial arms and then turns posteriorly above the tentorium, and extends through the thorax and the basal three abdominal segments. It comprises about 56% of the total length of the tract, and has a nearly uniform dark brown coloration which stops abruptly at its posterior end. In *Radinotatum carinatum* (HODGE, 1940) the fore-gut comprises 50% of the tract and extends to the second abdominal segment, while the fore-gut of *Locusta* extends only to the metathorax and makes about 42% of the tract (ALBRECHT, 1953).

The mouth and buccal cavity: The preoral cavity, though large in size, is mostly filled with a tongue-like hypopharynx suspended from its roof. Due to the slant face of this species the long axis of the buccal cavity is oblique to the main axis of the body. It is limited anteriorly by the epipharyngeal wall and laterally by the inner faces of the mandibles and maxillae. The posterior wall is the anterior surface of the labium, while dorsally the cavity is lined by the reduced sternal region of the head. This latter is represented by a narrow membranous area extending between the base of the hypopharynx and the bases of the mandibles and maxillae. At the upper end of the preoral cavity, anterior to the base of the hypopharynx, is the external opening of the stomodaeum, or the true mouth (Snodgrass, 1928).

The pharynx (oesophagus of TIETZ and CHAUVIN): This is a short tube (Ph) that extends upward, with a slight curving anteriorly. It merges into the oesophagus in a smooth terminal manner, and no blind pouch similar to that described by HODGE in *Radinotatum* (1940) and in *Leptysmia* (1943) is present. The pharyngeal wall is fairly muscular, and is thrown internally into six longitudinal irregular folds lined with a flexible intima. Fairly long, posteriorly directed dense setae cover the intima of the pharynx, and end more or less abruptly just before the end of this region. Similar setae are reported for *Melanoplus differentialis* in which the pharynx has no folds (HODGE, 1936). In *Locusta migratoria* (HODGE, 1939), *Leptysmia marginicollis* and *Opshomala vitreipennis* (HODGE, 1943) the pharyngeal intima is thrown into longitudinal folds but is devoid of setae. On the other hand, the pharynx of *Radinotatum carinatum* lacks both the folds and the setae (HODGE, 1940).

The oesophagus (crop of TIETZ and CHAUVIN, anterior part of crop of SNODGRASS): This is a straight tube (Oe) which is slightly arched in its anterior part. It originates as a sudden dilatation of the stomodaeum following the pharynx, and continues caudad into the crop. The oesophagus is characteristically different from the latter in the pattern of the intima which shows externally through transparency. On both sides of the oesophagus the intima is produced into obliquely diagonal folds. They are more strongly oblique cephalad, but become more inclined to the

vertical direction toward the posterior end. This differs from the condition in *Opshomala* (HODGE, 1943) where the diagonal folds are nearly parallel. On both the dorsal and ventral walls longitudinal folds are observed. The dorsal folds fork anteriorly to embrace few short transverse folds and then they fade gradually. The ventral folds extend from the pharynx to the crop.

All of these folds of the oesophagus carry minute, conical, posteriorly directed spines, arranged in rows running along the crests of the folds. The intima between the folds is quite bare except of very few scattered spines. In the middle region of the oesophagus the diagonal folds are more aggregated together. In the posterior third the spines are fewer and the folds lose their continuity, being crossed by short irregular furrows dividing each fold into pad-like parts. Later on, in the crop, these pads unite in the other direction to form the longitudinal folds. In *Radinotatum* the oesophageal intima is devoid of spines, while in *Dissosteira carolina* (TIETZ, 1923) the corresponding part is provided with spines except in its anterior part.

The crop (gizzard of TIETZ, posterior part of crop of SNODGRASS): The crop is a simple tube which resembles the oesophagus in diameter. Its inner wall is thrown into numerous longitudinal folds, about 42 in number, which are discontinuous anteriorly. The crest of each fold carries regularly scattered groups of posteriorly directed minute spines. The number of spines in each group varies more frequently from 4 to 8. Towards the posterior part of the crop the folds are continuous, the spines are fewer and soon disappear just before the proventriculus. In this region the longitudinal folds gradually collect to form the beginning of the six plates of the proventriculus.

The proventriculus: This region (CV) is short and poorly developed. Its wall is slightly thicker than the posterior region of the crop. Internally, the intima is produced into six longitudinal plates. These latter are V-shaped, the broader ends lying anteriorly while being simply rounded at their posterior edges and flat on their surfaces. Between each two plates extend three longitudinal minor folds as continuations from the crop. The proventricular plates carry minute conical spines which are numerous anteriorly but sparse posteriorly. In *Locusta* no spines are observed on these plates (HODGE, 1939), while those of *Opshomala* carry only minute rounded tubercles (HODGE, 1943).

The proventriculus partly projects into the ventriculus forming the stomodaeal invagination, or cardiac valve. Judging by the conditions seen in dissected specimens and the transverse sections made in this region, the proventricular plates do not occlude the lumen of the tract. Evidently therefore this organ can serve little as a filtering or a triturating organ.

Studying the stomodaeum of adult *Acrida* by dividing it into the foregoing regions was by following HODGE in his work on the alimentary canal of *Radinotatum carinatum* (1940), *Leptysm marginicollis* and *Opshomala vitreipennis* (1943). On the other hand, other authors, like TIETZ (1923) and SNODGRASS (1928), both working on *Dissosteira carolina*, and CHAUVIN (1941) on *Schistocerca gregaria*

divided the stomodaeum adopting different plans. TIETZ, though in his general considerations followed a plan similar to what is adopted here, yet in his details he obliterated the pharynx and regarded the alimentary tract to begin with the oesophagus. SNODGRASS divided the stomodaeum into pharynx, crop and proventriculus, regarding both regions here designated as oesophagus and crop as being one region, the crop.

The mesenteron

This section of the tract is recognized by its wall being white and translucent, and by the gastric caeca whose points of attachment denote its anterior limit. On the other hand, the Malpighian tubes, which are proctodaeal structures, mark it posteriorly.

The ventriculus: This is a simple straight cylinder (Mes) that comprises about 10.5-11.5% of the length of the whole tract. Similarly short ventriculus is also recorded in *Opshomala* (11%), *Locusta* (14%) and *Dissosteira* (16%), while it is longer in *Leptysmia* (24%), *Melanoplus* (24%) (HODGE, 1936) and *Radinotatum* (25%).

Externally the wall is smooth and glistening, with a more or less whitish translucent appearance. Internally the wall is almost regular, with no folds. It is lined with a soft velvety epithelium which starts well within the groove of the cardiac valve for the formation of the peritrophic membrane.

The gastric caeca: These organs, sometimes called diverticula or appendices ventricularis, are six in number and open independently into the anterior end of the stomach. Each caecum comprises two oppositely directed blind parts, an anterior finger-like lobe and a posterior small pouch with a single point of attachment to the ventriculus. The anterior lobes are sub-equal in length, three of them being little shorter than the others. The posterior pouches are more slender and less variable in length. Internally the wall is thrown into numerous longitudinal folds. The openings of the caeca are large apertures which are partly hidden by the stomodaeal invagination. They are so arranged that a line drawn through them would encircle the tract.

The longitudinal axis of the caeca run parallel with that of the alimentary tract to which they stick closely. On the anterior tip of each caecum is inserted a fine ligament that extends anteriorly to rest on the pronotum. These ligaments are arranged in two sets, one on either side, each with a common stalk. From the stalk of either side arises also another ligament which is inserted on the stomodaeum about the region of the stomachic ganglion. To these ligaments SNODGRASS (1928) offers the term "posterior protractors" of the gastric caeca and crop respectively.

The proctodaeum

The proctodaeum of *Acrida* extends from about the middle of the fourth abdominal segment to the anus. Four proctodaeal regions may be distinguished: a short pylorus, a long sac-like ileum, a narrow usually bent colon, and the rectum.

The pylorus (pyloris, pyloric valve, proctodaeal valve): This comprises the anterior most part of the hind intestine (PV) and when viewed from the inner surface, it appears in the form of a transverse groove. At the bottom of the groove are twelve oval apertures, each belonging to a group of Malpighian tubes. This groove is partly hidden by the overhanging posterior margin of the ventricular epithelium. Externally the longitudinal muscle fibres of the ventriculus continue caudad on the pyloric wall where they collect to form twelve bands that pass between the bases of the Malpighian tube groups. Soon they end on the posterior margin of the pyloric region where other six longitudinal bands take their origin.

Similar to the cardiac valve, the pyloric valve is not an efficient one, as might be deduced by its structure, or as evidenced by the fact that in none of the specimens dissected the amount and condition of the food in the ventriculus and the ileum seem to vary much. Similar non-efficient valves were also observed in some other Acridids, e.g. *Leptysmia* (HODGE, 1943).

The ileum: This is a straight sac-like tube that tapers somewhat posteriorly. Internally the wall of the ileum is thrown up into twelve longitudinal folds. In-between them extend some oblique folds giving the ileal wall a wrinkled appearance. On the outer wall six conspicuous bands of longitudinal muscles, originating at the pyloric region, extend along the ileal wall. These bands lie opposite to the furrows between the internal folds, each alternating with two of the latter. A similar number of muscle bands is observed in *Dissosteira* (TIETZ, 1923) and *Locusta* (HODGE, 1939), while in *Leptysmia* and *Opshomala* the longitudinal muscles of the ileum form twelve bands.

The colon: This is a short narrow tube (Col) occupying the sixth segment, and sometimes forming an S-shaped loop. In some specimens, however, it is quite straight with the posterior part slightly curving upward to join the rectum. The wall of the colon is fairly thick, muscular and opaque, with the six longitudinal muscle bands of the ileum continuing along its length. Internally its wall is thrown into twelve longitudinal prominent folds. This number of folds differs from the condition in *Dissosteira* and *Opshomala* where the folds of the colon are only six. Just before merging into the rectum these twelve folds coalesce gradually into six major folds.

The rectum: At the end of the colon the alimentary canal dilates to form an elongated ovoid rectal sac which is followed by a narrow short tube, the rectum proper.

The rectal sac (Rs) is nearly as wide as the ileum, and is easily recognized by its smooth and translucent wall. Externally the six longitudinal muscle bands of the colon continue down its wall. Alternating in position with these bands are the internal six rectal papillae which show externally through transparency. Each papilla is a low elevation, broadest at the middle region of the sac and tapers toward both ends. The edges of these papillae possess a brown colour.

Posteriorly the rectal sac terminates by a very short narrow tube, the rectum proper (Rp), which is subequal in diameter to the colon. The same six bands of longitudinal muscles continue down the sides of this region as well. The inner surface is thrown into twelve incised longitudinal folds which start at the posterior end of the rectal papillae and continue as six major and six minor folds. These folds tend to smoothen down and end slightly anterior to the anus.

THE SALIVARY APPARATUS

The salivary organs of *Acrida* (Fig. 2) consist of two acinous glands and a pair of lateral ducts leading forward to the buccal cavity. Each gland is made up of 50-55 white acini (ac), roughly spherical in shape. These acini are arranged in about six main grape-like clusters spread out on the thoracic venter below the ventral diaphragm, and end slightly postero-lateral to the metathoracic ganglion. However, the form and arrangement of the clusters do not always appear to be symmetrical.

Each glandular acinus has a fine efferent duct (ed.) Efferent ducts of one group of acini unite to form a common efferent duct which joins the main lateral salivary duct. The lateral ducts (ld) extend anteriorly in a more or less sinuous course. They converge in the cervical region where they pass below the ventral nerve cord and unite together just below the suboesophageal ganglion. The short median duct (cd) thus formed opens on the tip of the hypopharynx.

THE MALPIGHIAN TUBES

These excretory organs join the digestive tract onto twelve discrete areas of the ventricular wall immediately in front of the pylorus. These areas are arranged in an interrupted circle, and from the centre of each area arises a group of 10-18 tubes. The members of each group spring from one point in a radiating manner (Fig. 3,A), all lying in one level parallel with the surface of the alimentary tract. Then those tubes which are directed anteriorly and anterolaterally soon curve posteriorly. Later on some tubes may curve and complete their course in the anterior part of the body cavity, while the remainder continue caudad.

The Malpighian tubes of *Acrida* are fine thread-like sinuous structures, 165-175 in number, arranged in twelve groups of 10-18 tubes each. They have a yellow pigmentation throughout most of their length, though near their bases no colour is observed. They are simple unbranched and run independently along their course, but are much tangled together. In few examples, two neighbouring tubes were found to coalesce near their insertion to form a very short common tube leading into the common pore of the group. Generally the distal apices of the tubes swim

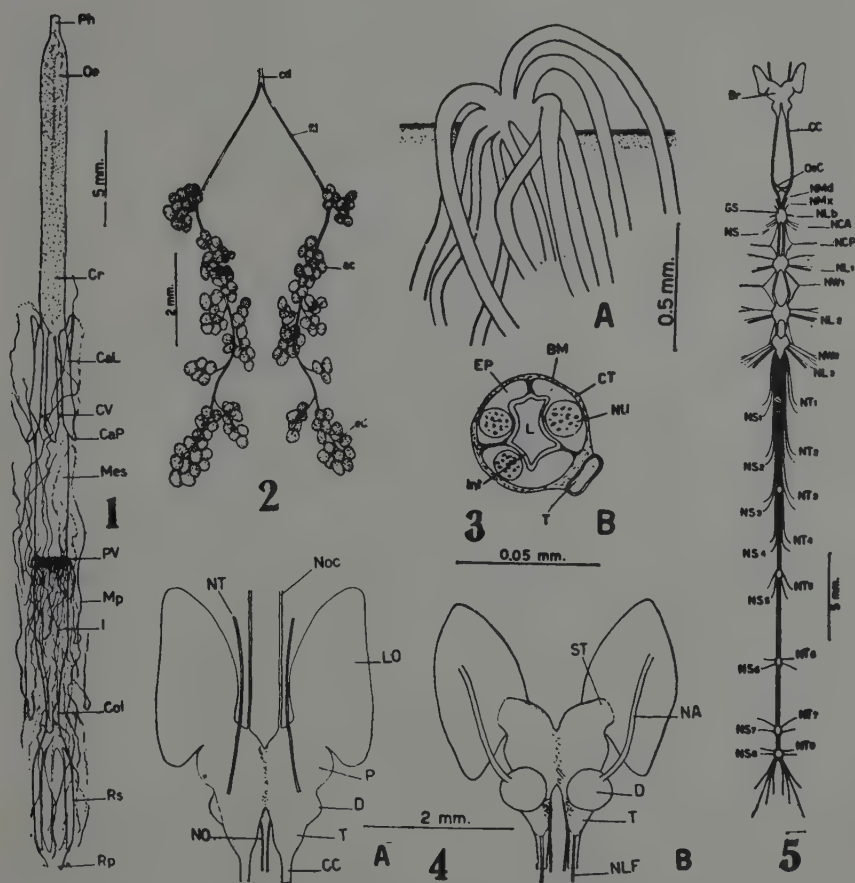


FIG. 1: Alimentary canal (CaL, anterior lobe of caecum; CaP, posterior pouch of caecum; Col, colon; Cr, crop; CV, cardiac valve; I, ileum; Mes, ventriculus; Mp, Malpighian tubes; Oe, oesophagus; Ph, pharynx; PV, pyloric valve; Rp, rectum proper; Rs, rectal sac). — FIG. 2: Salivary apparatus (ac, acinus; cd, common salivary duct; ed, efferent duct; ld, lateral salivary duct). — FIG. 3: Malpighian tubes (A, a group; B, Transverse section in a tube. BM, basement membrane; CT, connective tissue; EP, epithelium; Int, intima; L, lumen; NU, nucleus; T, trachea). — FIG. 4: Brain (A, posterior view; B, anterior view: CC, circum-oesophageal connective; D, deutocerebrum; LO, optic lobe; NA, antennary nerve; NLF, labro-frontal nerve; NO, occipital nerve; Noc, ocellar nerve; NT, tegumentary nerve; P, protocerebrum; ST, stalk; T, tritocerebrum). — FIG. 5: Central and peripheral nervous system (Br, brain; CC, circum oesophageal connective; GS, sub-oesophageal ganglion; NCA, anterior cervical nerve; NCP, posterior cervical nerve; NL1-3, leg nerves; NLb, labial nerve; NMD, mandibular nerve; NMx, maxillary nerve; NS, nerve to salivary glands; NS 1-8, sternal nerves; NT 1-8, tergal nerves; NW, wing nerve; OeC, oesophageal commissure).

freely in the body cavity, yet in many instances some of the tubes have their apices stuck to the wall of the alimentary tract, especially the ventriculus.

In cross-section (Fig. 3,B) the tubes are about 0.03-0.06 mm. in diameter. Their cells are provided with prominent nuclei (Nu) and distinct cell walls, and rest on a very thin basement membrane (BM). Each tube is in close contact with a fine trachea (T) that winds itself about the tube.

THE NERVOUS SYSTEM

A. The central and peripheral nervous system

The central nervous system in *Acrida*, similar to that in most other Acridids (NESBITT, 1941; ALBRECHT, 1953), consists of the brain, the suboesophageal ganglion, three thoracic and five abdominal ganglia (Fig. 5). The ventral nerve cord lies in the ventral body sinus below the ventral diaphragm to the surface of which the peripheral nerves tend to adhere.

The brain

The brain in *Acrida* parts the normal position over the oesophagus and is displaced far upward in the narrow head capsule to lie just between the compound eyes. It is somewhat antero-posteriorly compressed and almost completely covered by air sacs and muscles of the head. Its colour is cream when seen in water dissection, and is plainly divided into the three paired primary divisions.

(a) *The protocerebrum*: This is the largest and dorsalmost part of the brain (Fig. 4, P). Each protocerebral lobe is more or less spherical in shape. On its dorso-lateral part it carries an optic lobe (LO) to which it is broadly connected together by a short broad stalk (St.). The protocerebrum gives off three ocellar pedicels (nervi ocellarii) (NOc). Two of these nerves arise on the dorsal surface and proceed to the lateral ocelli. The third pedicel, for the median ocellus, originates on the anterior surface, from a low point in the median furrow that separates the two cerebral lobes.

The optic lobes are ovoid and nearly twice as large as the protocerebral lobes. They lie close to the heavily pigmented ommatidia. The optic nerves (nervus opticus), joining the optic lobes with the ommatidia, are therefore inconspicuous in gross dissection.

(b) *The deutocerebrum*: This comprises a pair of widely separated spherical lobes (D) bulging on the anterior aspect of the brain just antero-ventral to the protocerebrum. Each of these pendant lobes gives rise to a rather thick antennary nerve (nervus antennaris) (NA) that emerges from the dorsal aspect of the lobe. This nerve proceeds dorsally into the respective antenna where it forks into two trunks which are said to be separate sensory and motor branches (SNODGRASS, 1935). No accessory antennary nerves as those described for some other Acridids by NESBITT (1941)

were observed in the present grasshopper. It was also not observed in *Locusta* (ALBRECHT, 1953).

(c) *The tritocerebrum*: It is composed of two conical lobes (T) attached by their bases to both the lower aspect of the protocerebrum and the posterior surface of the deutocerebrum, and lead imperceptibly with their tips into the circum-oesophageal connectives (CC). A tegumentary nerve (nervus tegumentalis) (NT) arises posteriorly near the base of each tritocerebral lobe, runs close to the protocerebrum toward the dorsal part of the head (fastigium) where it branches. The labro-frontal nerve (nervus labro-frontalis) (NLF) leaves each lobe just in front of the circum-oesophageal connective. This nerve bifurcates about midway to the suboesophageal ganglion giving an inner branch, the frontal connective (pars frontalis), to the frontal ganglion of the sympathetic system, and an outer branch, the labral nerve (pars labralis), leading into the labrum.

Joining the circum-oesophageal connectives, is a fine nerve, the tritocerebral (or post-oesophageal) commissure which embraces the pharynx posteriorly. From the middle of this commissure two unbranched fine nerves are given each to the circum-oesophageal connective of its side, and are said to innervate the neurilemma of the latter (SNODGRASS, 1935). The latter author recorded a similar arrangement in the grasshopper *Dissosteira carolina*. On the other hand, JANNONE (1940) recorded a post-oesophageal commissure in *Dociostaurus* innervating the dilators of the stomodaeum. However, both types were found to co-exist in *Locusta* (ALBRECHT, 1953). Arising mesally, near the cleft of the tritocerebral lobes, is a pair of occipital nerves (nervi ganglii occipitalis) (NO) to the sympathetic system.

The circum-oesophageal connectives

These are simple cylindrical trunks which, due to the displaced position of the brain, are fairly long. This differs from the condition in the other grasshoppers, e.g. *Locusta migratoria* (Albrecht, 1953), in which the brain rests directly above the stomodaeum. These connectives run ventro-caudad, slightly diverging from each other, and pass inbetween the anterior tentorial arms. Then they embrace the pharynx behind which they converge to join the suboesophageal ganglion.

The sub-oesophageal ganglion

This ganglion lies below the tentorium, just above the mouth parts posteriorly. It is ovoid, with the anterior border slightly narrower than the posterior. Dorsally it is more or less flattened while it is strongly convex ventrally.

The suboesophageal ganglion is considered to be composed of the united ganglia of the three primitive gnathal segments. It follows that, though fused, it will continue to innervate the three segments bearing the mouth parts. This being the case, there are three pairs of nerves for these segments, besides other finer nerves for the hypopharynx, salivary glands and the cervical region. The most anterior nerves leading into the mandibles take their origin directly below the circum-oesophageal connectives. Arising between the mandibular nerves, at the antero-ventral

end of the ganglion, is a median fine nerve supplying the hypopharynx. ALBRECHT (1953) mentions a pair of such nerves for the hypopharynx in *Locusta*. The maxillary nerves arise from the mid-lateral margins of the ganglion, while the labial nerves arise somewhat posteriorly. Arising likewise on the postero-lateral margins of the ganglion are two pairs of tenuous nerves, one to the anterior part of the neck and back of the head, while the other ramifies on the salivary glands in the prothorax.

All the previously mentioned nerves take their origin on the ventral and ventro-lateral surfaces of the ganglion. From its dorsal surface two fine nerves spring just dorso-lateral to the thoracic connectives. They run caudad and join a similar pair from the prothoracic ganglion to form a plexus on either side. This innervates the posterior region of the neck and the anterior part of the prothorax.

The prothoracic ganglion

All the thoracic ganglia are relatively large, compared with the size of the brain and the other ganglia. They tend to be compressed dorso-ventrally and expand laterally.

The two connectives leading posteriorly from the suboesophageal ganglion pass over the neck membrane and join the anterior margin of the first thoracic ganglion. This latter is bilobed in appearance, broader than long, and lies closely anterior to the prothoracic furca. Apart from the anterior and posterior connectives, this ganglion gives off five pairs of nerves. These comprise an anteriormost pair which forms the plexus by joining the posterior nerves of the suboesophageal ganglion. Then follows a next pair which springs off near the antero-lateral corners of the ganglion and innervates the prothoracic muscles. The third is a pair of stout trunks associated with a finer pair, arising dorsal to it, and both extend into the prothoracic legs. Posteriorly, a slender pair arises latero-dorsal to the hind connectives and extends posteriorly to join a similar pair from the mesothoracic ganglion. The resulting nerves extend to supply the tegmina.

The mesothoracic ganglion

This ganglion lies just anterior to the mesothoracic furca. It is similar in shape but slightly larger than the prothoracic ganglion to which it is joined by a pair of stout connectives. These connectives are more widely separated in their insertion on the mesothoracic ganglion than on the prothoracic one.

Similar to that of the prothorax, this ganglion gives off five pairs of nerves, one forming the plexus of the tegmina, the next supplying the mesothoracic muscles, then the two pairs of the legs, and a posterior pair that forms the plexus of the wings.

The metathoracic ganglion

This is the largest of all ganglia in the grasshopper's body, and lies anterior to the metathoracic furca. It is pear-shaped and longer than the second thoracic ganglion to which it is connected by two short stout connectives. The distance

between the meta- and mesothoracic ganglia is about half that separating the meso- and prothoracic ganglia.

This ganglion actually represents a metathoracic-abdominal ganglion complex, including the metathoracic ganglion together with the ganglia of the basal three abdominal segments which it still innervates. HODGE (1943) regards the abdominal ganglia to form the posterior conical part of this complex.

Due to this constitution, nerves arising from this ganglion can be distinguished into two main groups:

(1) *Thoracic nerves*: These are four pairs. The anteriormost pair forms the plexus of the wings. This is followed by a pair of many branched nerves supplying the metathoracic muscles and the salivary glands. Then follows a pair of stout trunks associated with another finer pair for the hind legs.

(2) *Abdominal nerves*: These are six pairs extending into the first three abdominal segments. Each segment is supplied by a pair of nerves on either side; each pair comprises a tergal nerve and a sternal nerve, the former arising anterior to the latter. The tergal nerve of the first abdominal segment gives off a fine branch to Muller's organ of the tympanal apparatus.

The abdominal ganglia

In *Acrida* there are five abdominal ganglia which are all small, ovoid and somewhat dorso-ventrally compressed. They are sub-equal in size except the last one which is rounded and larger than the others, but still smaller than the thoracic ganglia. Each abdominal ganglion supplies the respective segment by a pair of tergal and a pair of sternal nerves.

The first ganglion is located inbetween the second and third segments. It gives off nerves to the fourth segment. The second ganglion lies in the fourth segment and supplies the fifth. The third ganglion is located inbetween the fifth and sixth segments and supplies the latter. The fourth ganglion lies in the anterior part of the seventh segment which it innervates. In the female the sternal nerve of this segment gives off a fine branch to the respective oviduct.

The fifth ganglion, the last of the series, lies near the anterior margin of the eighth sternum. From its anterior part arise the two pairs of tergal and sternal nerves to the eighth segment. In the female the sternal nerves give also branches to the spermatheca, common oviduct and the ventral ovipositor valves. From the posterior part of the ganglion arise two identical groups of nerves, one on either side. The nerves of each group are held closely together near their roots by a fatty connective membrane. Each group comprises a nerve to the ninth and tenth terga and the epiproct, a nerve to the rectum and anal sphincter, a nerve to the paraproct and cercus, and lastly a nerve to the genitalia. In the female this latter nerve branches to supply the three ovipositor valves. In the male it innervates the accessory glands, ejaculatory duct and the musculature of the phallic organ.

Caudad to the metathoracic ganglion both connectives of the ventral cord become more slender and run close to each other. They are encircled by a sheath of fatty connective tissue which obscures their double nature.

B. The sympathetic nervous system

This system includes:

(a) The stomodaeal, or stomatogastric system supplying the anterior part of the gut and some neighbouring structures.

(b) The ventral sympathetic system, including the splanchnic nerves to the hind gut and reproductive organs.

The stomodaeal nervous system

This system (Fig. 6) is composed of the usual parts: two frontal connectives (pars frontalis), a frontal ganglion (precerebral, buccal), a median recurrent nerve (anterior recurrent), occipital ganglion (hypocerebral, pharyngeal, oesophageal, subcerebral, anterior visceral), two pairs of posterior recurrent nerves (oesophageal), a pair of stomachic ganglia (ingluvial, splanchnic, visceral, vagus, gastric), a pair of oesophageal ganglia (corpora cardiaca, anterior pharyngeal or oesophageal, pharyngeal bodies), a pair of corpora allata (posterior lateral oesophageal), and a pair of occipital nerves.

The stomodaeal nervous system arises from the brain by the two frontal connectives (PF) which join the ventro-lateral margins of the frontal ganglion (GF). This latter is roughly triangular in shape and lies close to the anterior wall of the pharynx in the middle line of the head. Besides the frontal connectives, the frontal ganglion sends off a pair of fine nerves (NCl) to the clypeal region.

Dorsally a short anterior recurrent nerve (NRA) extends from the frontal ganglion along the median line to join the occipital ganglion (GH) near the dorsal end of the pharynx. The latter ganglion gives off two pairs of posterior recurrent nerves, an inner and an outer pairs. The inner nerves (NRPI) are short and break into numerous branches on the dorso-lateral walls of the oesophagus to which they tightly adhere. The external nerves (NRPE), on the other hand, are unbranched and much longer. They run near to, but free from, the stomodaeal wall till the stomachic ganglia (GG) which lie on the lateral walls of the crop just anterior to the gastric caeca. The stomachic ganglion is a small lenticular body. It receives the posterior recurrent nerve anteriorly, while several nerves, 6-8 in number, leave its lateral and posterior margins and ramify amongst the gastric caeca.

In *Acrida* the oesophageal ganglia (GO), together with the corpora allata (CA), are displaced far up from their usual position around the occipital ganglion. They here lie inbetween the circum-oesophageal connectives, about midway to the brain. The oesophageal ganglia are elongate, laterally compressed fragile bodies, more or less ovoid in lateral view and taper toward their lower ends. They closely adhere to the termination of the aorta which opens inbetween them and commonly

obscures their nature. These ganglia join, at their tapering tips, a pair of very fine nerves that extend to the occipital ganglion. Another pair of nerves, the occipital nerves (NO), arise at the anterior margins of these ganglia and extends to the brain.

The corpora allata are two spherical bodies that lie close to the oesophageal ganglia to which they are connected by a pair of very short nerves (nervi corporum allatum) (NCA). The corpora allata, like the oesophageal ganglia, are connected to the occipital ganglion by a pair of very fine nerves.

The corpora allata are two spherical bodies that lie close to the oesophageal ganglia to which they are connected by a pair of very short nerves (nervi corporum alatum) (NCA). The corpora allata, like the oesophageal ganglia, are connected to the occipital ganglion by a pair of very fine nerves.

The ventral sympathetic nervous system

Very fine longitudinal median nerves are to be found lying between the paired interganglionic connectives. These nerves receive several names: brides épinières (LYONET, 1746), super-added series (NEWPORT, 1832), sub-intestinal (oesophageal) nervous system (several authors). Each median nerve arises from the posterior part of the ganglion anterior to it and gives off two lateral branches. It may end in this bifurcation (like the case with those nerves given off from the suboesophageal, prothoracic and mesothoracic ganglia), or continue backward to join the anterior part of the ganglion posterior to it.

The lateral branches of the median nerve given off from the suboesophageal ganglion extend to the neck membrane. Those of the prothoracic and mesothoracic ganglia extend to ramify in the vicinity of the first and second thoracic spiracles respectively. From the metathoracic ganglion three independant median nerves are given off from the dorsal surface of its posterior conical part. One of these nerves, the shortest, ends in lateral branches extending to the first abdominal spiracles. Another nerve ends also in a bifurcation forming lateral branches to the second abdominal spiracles. The third and most posterior nerve extends backward within the sheath enclosing the nerve cord to join the first abdominal ganglion. On its course it gives off two lateral branches that penetrate the sheath dorsally in the second abdominal segment and extend to the third abdominal spiracles. Posteriorly the following median nerves are similar in plan to the last described one, excepting of course the median nerve of the last abdominal ganglion which is short and ends in the lateral branches supplying the eighth spiracles. All of the lateral branches of the abdomen pass along their course through the tissue of the ventral diaphragm, and therefore become exceedingly obscured.

The splanchnic nerves are more conspicuous. They leave the last abdominal ganglion and supply, in both sexes, the genital organs, the rectum and the anal sphincter. In addition to these, a branch of the sternal nerve of the penultimate ganglion of the female insect supplies the lateral oviduct of its side. A similar nerve was also observed in *Locusta* (ALBRECHT, 1953). Such nerve is of special interest

since it is commonly held that the splanchnic nerves originate only from the ultimate abdominal ganglion (IMMS, 1948).

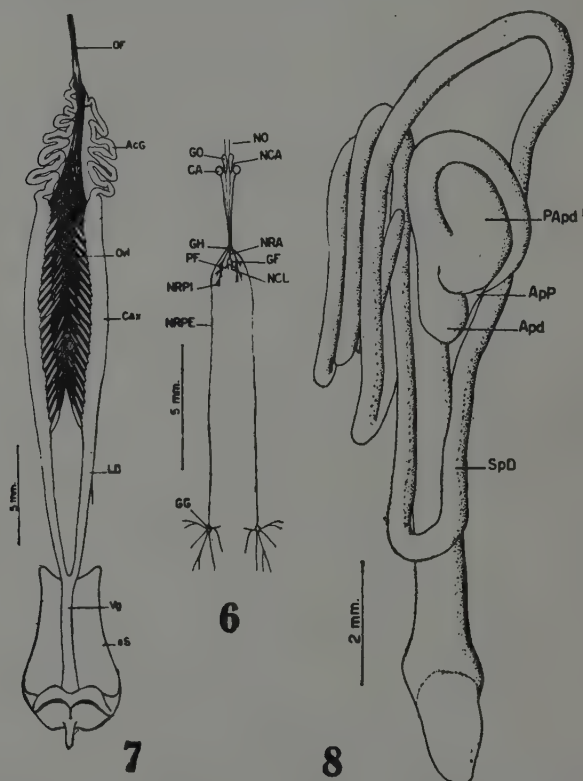


FIG. 6: Sympathetic nervous system (CA, corpora allata; GF, frontal ganglion; GG, stomachic ganglion; GH, occipital ganglion; GO, oesophageal ganglion; NCA, nervous corpusculum alatum, NCL; clypeal nerve; NO, occipital nerve; NRA, anterior recurrent nerve; NRPE, external posterior recurrent nerve; NRPI, internal posterior recurrent nerve; PF, pars frontalis). — FIG. 7: Reproductive system, female (AcG, accessory gland; Cax, calyx; LD, lateral oviduct; OF, ovarian filament; Ovl, ovariole; Vg, vagina; sS, subgenital plate). — FIG. 8: Spermatheca (Apd, apical diverticulum; ApP, apical pouch; PApd, preapical diverticulum; SpD, spermathecal duct).

THE REPRODUCTIVE SYSTEM

A. The female reproductive system

The paired ovaries lie in the dorsal part of the body cavity above the alimentary canal to which they are tightly applied by heavy tracheation. Each ovary

is made up of numerous ovarioles that extend close to each other, with their apices directed mesally and anteriorly (Fig. 7, Ovl). The apices of the ovarioles are produced into fine thread-like filaments which are closely adherent thus uniting the two ovaries into a single body.

Each ovariole consists of a linear series of follicles, containing 9-10 eggs in different developmental stages, the riper egg being the nearest to the oviduct. The riper eggs are yellow in colour while the others are white. The ovarioles open laterally into the calyces by extremely short pedicels, and are arranged in two more or less regular rows. An orange coloured epithelial plug, the so-called corpus luteum, is visible in each ovariole stalk.

For counting the number of ovarioles, ten female specimens were dissected, and the least number of ovarioles on one side was 68 and the greatest 77. The maximum difference between the two sides of any one specimen was 6, and the total number of ovarioles was 136-148 with an average of about 143. Among other Acridids wide variations are observed in the number of ovarioles. Albrecht (1953), records a mean number of 88 ovarioles in *Locusta*. In *Nomadacris* the average number is 174 ovarioles (ALBRECHT, 1956), while it is only 33 in *Dociostaurus* (JANNONE, 1940).

On maturation the ovarioles do not all contain mature ova. Some tubes, however, sometimes making about 50% of the total count, remain empty of such ova. These empty tubes are irregularly scattered among the mature ones, yet more often they alternate with them.

The lateral oviducts are cylindrical white tubes with fairly thick walls. They are closely adpressed to the alimentary tract, slant down and disappear beneath the ventral nerve cord inbetween the last two ganglia. Here they unite to form the vagina (Vg.) The latter is a short broad tube, flattened dorso-ventrally, with thick soft white walls. It lies in the middle line of the eighth sternum and opens posteriorly into the floor of the genital chamber.

The accessory glands (AcG), two in number are actual extensions of the paired calyces of the oviducts at their anterior ends beyond the ovarioles. They are pinkish white in immature ovaries, but become darker on maturation. They are heavily wrinkled and tend to coil up in an irregular manner. The terminal filament, forming the anterior end of each gland, fuses with that of the opposite side to form a median ovarian ligament (OF) that runs forward to join the aorta in the mesothorax.

The spermatheca comprises a long coiled tube terminating in an elongate pouch (Fig. 8). It arises as a slender tube from the spermathecal aperture on the dorsal wall of the genital chamber. This tube (SpD) runs cephalad for about 7.5 mm. and then turns by a U-turn to the posterior direction. Then it is tightly coiled and lies between the vagina and the nerve cord. Its coloration is milky white, and its length, with its pouch, averages 52 mm., the pouch measuring about 2.6 mm. The spermatheca is a sclerotised bilobed organ, composed of an apical (Apd) and

a preapical (PApd) diverticula. Both diverticula are enclosed in the membranous apical pouch (ApP) which lies dorsal to the coiled spermathecal duct.

B. The male reproductive system

The paired testes (Fig. 9, Tes) are closely adpressed to form a single body which generally occupies the third, fourth and fifth abdominal segments. This body, about 11 mm. long, lies dorsal to the alimentary canal to which it is tightly applied by heavy tracheation. Both testes consist of 34 tubular follicles which are nearly uniform in length, ranging about 6.3 mm. In diameter they are slightly narrower near the base and widen gradually toward their distal end where shortly before the tip each follicle tapers to a point. The number of follicles in *Acrida* is greater than that which HODGE (1943) recorded in either *Leptysma* (18 follicles) or *Opshomala* (20 follicles).

Each follicle is connected to the vas deferens of its side by a very short vas efferens. All the follicles of both testes extend in one direction and lie on an dbeside each other in two layers held together by a connective tissue, and thus appear dorso-ventrally flat. The arrangement of the follicles appears to be intermediate between the fountain and the radiating types described by LAIRD (1943).

The vasa deferentia (VDf) are slender tubes, about 20.8 mm. long and 0.14 mm. in diameter, that extend from the anterior tips of the testes caudad to join the ejaculatory duct (DEj). Their anterior ends are blind and somewhat inflated. All the follicles of each testis are joined to this inflated region which measures about 1.7 mm. long and 0.38 mm. in diameter and which is visible only in a ventral view of the testes. From between the apices of the vasa deferentia the testicular ligament (TL) extends cephalad to join the aorta in the mesothorax. Near the hind end of the testes the vasa deferentia diverge and slant ventrad and caudad around the alimentary tract and the accessory glands. Near the posterior end of the eighth segment each vas deferens curves mesad and then cephalad to join the respective antero-lateral corner of the ejaculatory duct.

The ejaculatory duct is a simple thick-walled tube (DEj), about 1.5 mm. wide at its anterior end where it receives the accessory glands and vas deferentia. It narrows to about 0.9 mm. posteriorly where it runs below the endophallic plates into a globular pouch-like structure, the ejaculatory sac, and then continues caudad into the copulatory apparatus.

The accessory glands are fragile tubes (AcG), 32 in number, attached to the expanded anterior part of the ejaculatory duct. They form coiled bundles, about 10 mm. by 2.5 mm., one on either side of the gut. In *Nomadaeris* (ALBRECHT, 1956) these tubes count also 32, but in *Locusta* (ALBRECHT, 1953) and in *Dociostaurus* (JANNONE, 1940) they are only 30. Both of these bundles are nearly equal in length and extend between the posterior region of the eighth segment and the middle of the sixth, with the left bundle displaced slightly forwards. Each bundle consists of 16 tubes of varying length, the longest of which when straightened out measures

about 33 mm., while the shortest measures 2.1 mm. When specimens are dissected in Ringer's solution some difference in colour of these tubes can be traced. Eight pairs are hyalinous, three of them being very short. Seven pairs of long tubes are hyalinous near their bases, but become milky-white distally. One pair of long white tubes, each of which is coiled and surrounded by a thin yellow membrane, are said to be the seminal vesicles (ALRBECHT, 1953)

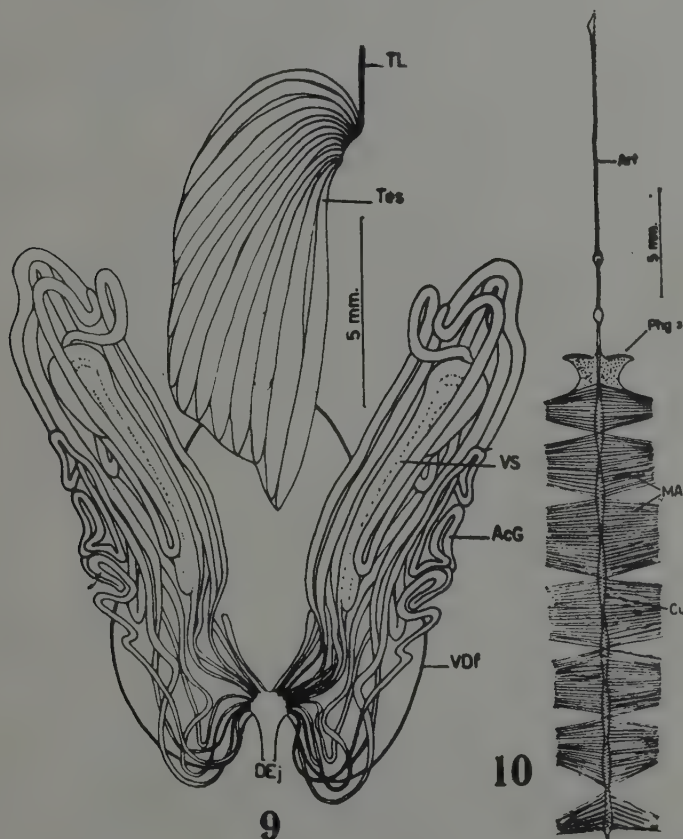


FIG. 9: Reproductive system, male (AcG, accessory gland; DEj, ejaculatory duct; Tes, testes; TL, testicular ligament; VDF, vas deferens; VS, vesicula seminalis). — FIG. 10: Dorsal vessel (Art, aorta; Cu, heart; MA, alary muscles; Phg 3, third phragma).

THE CIRCULATORY SYSTEM

The dorsal blood vessel (Fig. 10) extends in the dorsal line from the posterior end of the abdomen into the head. It is divisible, as usual, into the aorta (Art)

anteriorly and the heart (Cu) posteriorly, the latter being confined to the abdomen.

The heart runs in the pericardial sinus below the terga from which it is suspended by fine strands of tissue. Its ventral surface is closely adherent to the dorsal diaphragm, with the two dorsal tracheal trunks lying one on either side and supplying the heart with fine branches. Anatomically the heart is distinguished from the aorta by the presence of segmental dilatations, the chambers, which together with the ostia are present in the abdominal segments 2-9. The organ terminates blindly in the ninth and part of the tenth segments. There are eight pairs of alary muscles (MA) originating on the tergal plates and spreading out more or less fanwise over the surface of the dorsal diaphragm. The fibres of one side meet those of the opposite side on the ventral surface of the heart.

The aorta represents the thoracic and cephalic part of the dorsal vessel. It stretches from the first abdominal segment through the thorax, passing between the two lobes of each thoracic phragma, and then into the head. In the metathorax and mesothorax the aorta is dilated dorsally to form two diverticula lodged in the median scutellar cavities of these segments. These diverticula are particularly covered each with a thick padding of nephrocytic cells. The median ovarian, or testicular, filament is to be found connected to the ventral wall of the mesothoracic diverticulum. In the neck the aorta gradually leaves the dorsal position, and in the head it plunges mesally between the mandibular muscles and terminates on the middle of the frons by a wide, laterally compressed opening.

THE RESPIRATORY SYSTEM

The respiratory system of *Acrida*, as in other Acrididae, is composed of a complicated system of tracheae and air sacs, and communicates with the exterior by ten pairs of spiracles.

The spiracles

The thoracic spiracles

The first spiracle of the thorax is by far the largest of all spiracles in the body. It is contained in a small irregular plate, or peritreme (Fig. 11, Ptr), and lies on the lateral side of the membrane separating the prothorax and mesothorax where it is concealed by the posterior fold of the pronotum. The lower end of the peritreme is produced posteriorly and upward in a small free process (*a*) bearing on its base a flat-topped tubercle (*b*). The tubercle is a little higher than the lips of the spiracle to prevent the pronotum from resting too closely against the spiracle (SNODGRASS, 1929). The spiracular opening is an obliquely vertical slit with a slight curve and strongly protruding lips. The length of the slit is about 0.56 mm. in the male and 0.70 mm. in the female. The anterior lip (*c*) is rigid; its inner face is soft and deeply grooved. The posterior lip (*d*) is a weaker and freely movable flap, but it has a strongly

sclerotized marginal band which, when the spiracle is closed, fits into the groove of the anterior lip. The first spiracle opens into a shallow atrium from which arise two main tracheae, one dorsal (*f*) and one ventral (*g*). An internal bar (*h*) projects antero-ventrally from the posterior lip in the region between both tracheae causing the spiracle to appear of double nature. This bar terminates in a free process (*i*) on

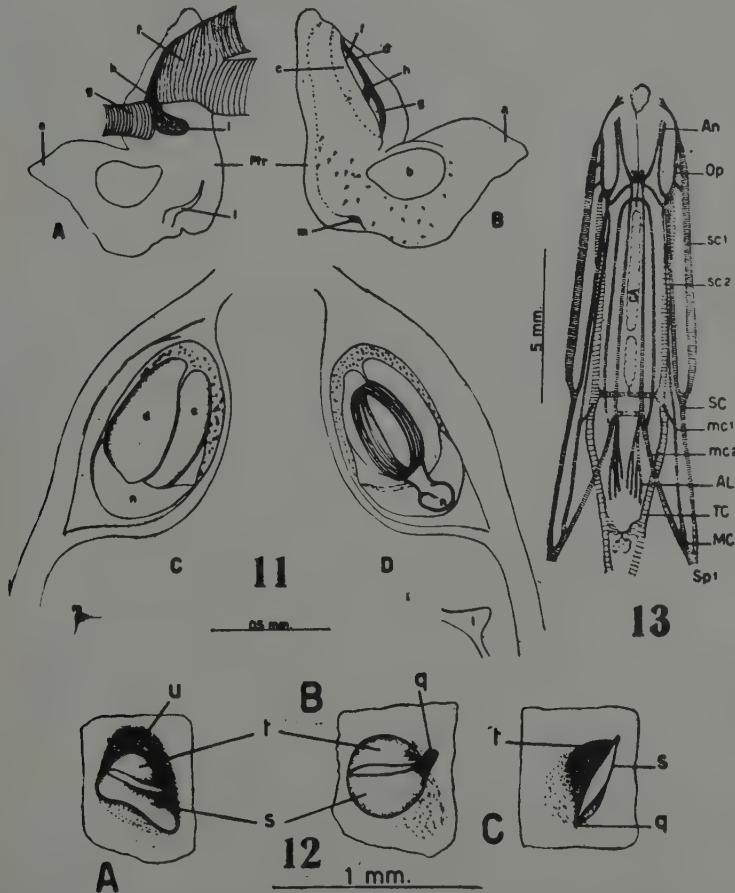


FIG. 11: Thoracic spiracles (A, B, first; C, D, second (inner and outer views): a, ventral lobe of peritreme; b, elevated process; c, anterior lip; d, posterior lip; f, dorsal trachea; g, ventral trachea; h, internal lever of posterior lip; i, head of lever; l, ventral internal process; m, pit; n, ventral lobe; Ptr, peritreme). — FIG. 12: Abdominal spiracles (A, first, outer view; B, first, inner view; C, 8th, inner view: q, manubrium; s, ventral or anterior atrial wall; t, dorsal or posterior atrial wall; u, thickening of tergal wall). — FIG. 13: Cephalic tracheae (AL, to stomodaeum; An, to antenna; CA, cephalic air sac; MC, median cephalic; Op, ophthalmic; SC, superior cephalic; Sp 1, 1st thoracic spiracle; TC, thoraco-cephalic).

which is inserted a short muscle. This latter takes its origin on a process (*l*) marked externally by a pit (*m*) on the lower region of the peritreme.

The second thoracic spiracle lies in the lower posterior angle of the mesothoracic epimeron where it is surrounded by a narrow membranous area. Externally, it presents two thick, elongate oval lips separated by an obliquely vertical cleft of about 0.33 mm. long in the male and 0.45 mm. in the female. Both lips are movable, though united ventrally in a sclerotized broad lobe (*n*). To this lobe is attached a short muscle that arises from a process (*l*) on the posterior dorsal margin of the mesocoxal cavity. The spiracular lips stand out prominently from the body wall, and between them is a shallow atrium from which arises a single trachea.

The abdominal spiracles

The spiracles of the abdomen (Fig. 12) are quite different from either of the thoracic spiracles. They are provided with no lips, but the body wall is directly inflected in each spiracle to form an open atrial chamber. The atrium leads by a narrow aperture at its inner end into the spiracular trachea. The longer axis of the first abdominal spiracle is obliquely horizontal, with the anterior end a little higher and broader than the posterior. The other spiracles are placed more vertical, with the dorsal end corresponding with the anterior end of the first one. In each spiracle one wall of the atrium is rigid and the other is movable. The rigid wall (*r*) is dorsal in the first spiracle and posterior in the others, and is strengthened by a thickening in the external body wall. The movable wall (*s*) is flexible because the body wall immediately external to it is somewhat weak and the two end walls of the atrial chamber are membranous. The posterior, or ventral, end of the movable wall is produced into a free process, the manubrium (*q*), that gives attachment to two opposite muscles. The average lengths of the eight abdominal spiracles of both sexes of adult *Acrida* are as follows: first, male: 0.26, female: 0.42; second, male: 0.21, female: 0.37; third, male: 0.14, female: 0.26; fourth, male: 0.14, female: 0.23; fifth, male: 0.14, female: 0.21; sixth, male: 0.11, female: 0.23; seventh, male: 0.11, female: 0.21; eighth, male: 0.16, female: 0.32.

The cephalic tracheal system

The upper portion of the head: This part is supplied on either side by two trunks. These originate at the upper chamber of the first thoracic spiracle as a large main tube which soon divides into a dorsal and a ventral branches.

The dorsal branch, the superior cephalic trachea (Fig. 13, SC) penetrates into the head in its uppermost region where it forks directly into two tubes. These run parallel to each other on either side of the dorsal edge of the inner plate of the mandibular adductor apodeme. They continue to join the ophthalmic trachea (Op), and along their course give branches to the adductor muscles. The ophthalmic trachea forms an incomplete ring around each eye and supplies the optic ganglion. The anterior arm of the ophthalmic trachea (An) proceeds into the respective antenna, while its dorsal arm proceeds to the fastigium where it ramifies.

The ventral branch, the median cephalic trachea (MC), soon divides to form two tubes. One branch (mc1) travels along the lower edge of the outer blade of the mandibular adductor apodeme giving off branches to its muscles. It joins the superior cephalic trachea near the brain. The second branch (mc2) passes through the occipital foramen with the alimentary canal. It then divides near the tentorium forming two tubes. One tube travels along the lower edge of the mandibular adductor apodeme giving off branches to its muscles. Slightly before the brain this trachea curves to join the corresponding one of the opposite side. Here it gives rise to a large median air sac, the cephalic air sac (CA), closely adpressed to the aorta. It also gives a fine branch to the fastigium where it ends in a small air sac. The other tube of mc2 joins the similar tube of the opposite side near the tentorium by a short transverse trachea. At this point two tracheae (AL) are given on either side to the ventral surface of the fore gut. Each main tube then proceeds to the under surface of the brain where it forms numerous air sacs around the latter. Below the brain it joins the ophthalmic trachea by transverse tubes and proceeds into the respective antenna.

The lower portion of the head: The two trunks of the thoracocephalic system (TC) which, in the thorax, run on either side of the ventral nerve cord, run into the lower region of the head. They curve laterally and unite in the frontal region, thereby forming a complete peripheral ring above the articulations of the mouth parts and giving off branches to them. Opposite to the frons, mesally, this transverse tube gives off an air sac. It also joins a sac-like tube from each of the ophthalmic rings near the anterior tentorial pits.

All the above mentioned cephalic tracheae receive air through the dorsal chambers of the first thoracic spiracles, with the exception of the thoraco-cephalic tracheae which receive air from both thoracic and the first abdominal spiracles.

The thoracic tracheal system

The dorsal thoracic tracheae: From each of the first abdominal spiracles (Sp3) arises a trunk (Fig. 14, DTT) that runs to the median surface of the dorsal longitudinal muscles where it divides into three main branches. These are distributed over these muscles, and all connect anteriorly with the main thoracic air sac (MTA) while still in the metathorax. This sac runs contiguous to the undersurface of the dorsal longitudinal muscles which it supplies with numerous branches. Just below the second phragma this air sac joins a branch that forms a plexus (plx2) receiving tracheal branches at different muscle levels and finally connecting with the second thoracic spiracle. Also, near the first phragma, this air sac joins indirectly the first thoracic spiracle. Finally the air sac ends in a fine branch and joins the upper cephalic trunk near the occipital foramen.

The dorsal longitudinal muscles having been removed, a pair of arched tracheae (Ar1, Ar2) may be seen. These originate at the ventral chamber of the first thoracic spiracle, run on the surface of the dorso-ventral muscles of the mesothorax. Poster-

iorly they join the plexus below the second phragma. In the metathorax similar position is occupied by an arched tube (Ar3) which originates at the plexus of the second thoracic spiracle and ends at the first abdominal spiracle. Ventrally the arched trunks in both the meso- and the metathorax send tracheae and air sacs to supply the thoracic muscles and join the various parts of the ventral system.

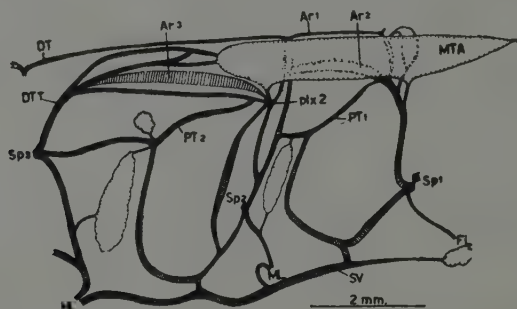


FIG. 14: Thoracic tracheae (Ar 1-3, arched tracheae; DT, dorsal abdominal trunk; DTT, dorsal thoracic trachea; FL, to fore leg; HL, to hind leg; ML, to mid leg; MTA, main thoracic air sac; plx2, plexus of second spiracle; PT, principal trachea; Sp, spiracle; SV, subventral trunk).

Upon removing the dorso-ventral muscles a more complicated tracheal system is exposed. In general, this consists of a principal trachea (PT1) which indirectly connects the first thoracic spiracle with the plexus of the second thoracic spiracle, and a trachea (PT2) which connects the latter plexus with the first abdominal spiracle. Each of the meso- and metathoracic tubes sends off a ventral branch which connects with the subventral trachea (SV). The trunks arising from the second thoracic spiracle supply a number of peripheral air sacs lying under the cuticle of the meso- and metapleura.

From the ventral chamber of the first thoracic spiracle a trachea (FL) is given off to the foreleg. From the second thoracic spiracle a branch (ML) is given to the middle leg. On its course it connects with an air sac on the dorso-ventral muscles. From the first abdominal spiracle a branch (HL) is sent into the hind leg.

The ventral thoracic tracheae: This group consists mainly of two pairs of trunks. The most ventral thoraco-cephalic tracheae (Fig. 15, TCT) run on either side of the ventral nerve cord. They are linked together at three points where short branches are sent to the thoracic ganglia. They also supply the first and third pairs of legs, and continue into the head as described before. The subventral (superior or supraventral) pair of trunks (Fig. 14, SV) originates at the first pair of thoracic spiracles and runs posteriorly supplying the three pairs of legs. They also supply the salivary glands and are connected to the dorsal thoracic and thoraco-cephalic tracheae.

The abdominal tracheal system

A large number of air sacs and tracheae is contained in the abdomen, yet they can be distinguished into four groups:

(a) *Spiracular (pleural) system*: This is a pair of longitudinal tracheae (fig. 15, SpT) running along the tergo-pleural side of the abdomen and is connected by short tubes to the abdominal spiracles. From these tracheae originate all the branches found in the abdomen. Considering the number and nature of these branches, it is

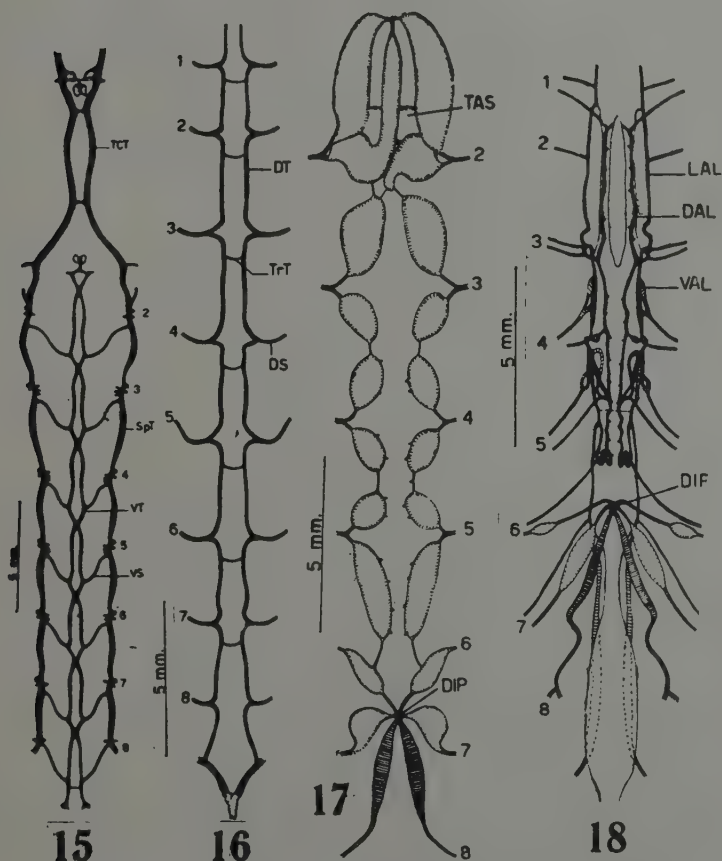


FIG. 15: Spiracular and ventral tracheae (TCT, thoraco-cephalic; SpT, spiracular; VS, ventro-segmental; VT, ventral trunk). — FIG. 16: Dorsal tracheae (DS, dorso-segmental; DT, dorsal trunk; TrT, transverse connective). — FIG. 17: Air-sac system (DIP, dorsal ileal plexus; TAS, tympanal air sac). — FIG. 18: Alimentary canal tracheae (DAL, dorsal trunk; DIP, dorsal ileal plexus; LAL, lateral trunk; VAL, ventral trunk).

found that those branches of segments 3, 4 and 5 are only similar. In each of these segments five transverse tubes are given off. One, the dorsosegmental trachea (DS), runs dorsally to connect with the longitudinal dorsal trachea. Arising close to it is a similar tube which soon forks into two branches each joining a large air sac. Slightly posterior to these are two tubes supplying the alimentary canal. Then follows a tube (VS) that leads to the ventral longitudinal trunk.

The first spiracle gives off seven tubes, four extending into the thorax and the other three into the first abdominal segment. The latter group comprises the dorso-segmental trachea, a short trunk that soon forks into two tubes both supplying the alimentary tract, and a short tube to the tympanal air sac. Arising from the dorso-segmental tube, near its origin, is a fine branch that runs close to the tympanal capsule to join the base of the dorso-segmental tube of the second spiracle.

The second spiracle differs from a typical one in that it sends a trachea to the hind leg, a single trachea to the alimentary canal, and the dorso-segmental trachea together with both air sacs arise from a common tube. Just anterior to the second abdominal spiracle the spiracular trunk curves mesally and proceeds anteriorly as the thoraco-cephalic trunk.

The sixth spiracle differs in that it gives only one air sac, and also one tube to the alimentary tract. From the seventh spiracle is given a single alimentary trachea which forks near the tract into a dorsal and a ventral tubes. Also the dorso-segmental tube arises from a common base together with a single air sac. In the eighth segment the dorso-segmental tube, a single air sac and a single alimentary trachea all arise by a common base together with a branch given to the tenth tergum. The air sac does not join the visceral system, but is connected to the dorsal one.

(b) *Dorsal (tergal) system*: This system (Fig. 16) consists of two dorsal trunks that run one on either side of the heart, in close approximation to the alary muscles. They are connected in each abdominal segment each to the respective spiracular trunk by the dorso-segmental trachea. To each other, the dorsal trunks are linked in each of the abdominal segments 1-7 by a transverse fine trachea (TrT). The latter forms a bridge over the heart near the posterior edge of the tergum. The dorsal tracheae continue anteriorly into the thorax (Fig. 14, DT) where they join the dorsalmost arched tracheae of the mesothorax. Posteriorly they extend into the epiproct where they end together.

(c) *Ventral (sternal) system*: This consists of two trunks (Fig. 15, VT) that extend below the ventral nerve cord. Instead of being connected together by transverse tubes, the ventral trunks coalesce in points near the anterior sternal edges of segments 2-8. They are segmentally connected to the spiracular tracheae by the sternal tubes. Little beyond the region where the ventral trunks receive the sternal junctions of the eighth spiracle, in the male, they are connected to each other by a short transverse tube posterior to which they ramify to supply the aedeagus. In the female this junction is not observed. In the first abdominal segment, after receiving

the sternal tubes, they unite with each other and end in two fine branches terminated each in an air sac between the metafurca.

(d) *Visceral system*: This comprises two distinct series:

(1) *The air-sac system* (Fig. 17): From each of the spiracles 2-5 two air sacs take their origin by a single trunk that forks into two, each connecting with a sac. On the other hand, each of the first, sixth and seventh spiracles gives only one sac to join this system. The eighth spiracles are connected to the air-sac system at the dorsal ileal plexus (DIP), each by a stout sac-like trunk. In the first abdominal segment two large tympanal air sacs (TAS) are given off. They completely occupy the cavity of this segment above the alimentary canal, with their outer walls pressed close against the tympana.

The anterior sacs of the second segment of both sides, together with one of their posterior sacs, extend anteriorly into the metathorax where they connect together mesally. Posteriorly the air sacs of the visceral system are interconnected in an alternating manner, i.e. the posterior sac of the second pair with the anterior one of the third pair and so on. But both sacs of a pair are not connected together except through their origin. Sacs of the sixth and seventh segments join through the ileal plexus. In the female, sacs of both sides are interconnected by fine tubes. In the male, such interconnection is inconspicuous except in the second and the third segments, since the more posterior connections join the testes.

(2) *The alimentary tracheae* (Fig. 18): With the exception of branches of the median cephalic tracheae to the stomodaeum, all the tracheae connecting with the alimentary canal arise from the abdominal spiracles. From the first spiracle two tubes run to the tract near the apices of the mesenteric caeca, one connecting with the lateral alimentary trachea (LAL), and the other with the dorsal one (DAL). These longitudinal tubes extend inbetween the mesenteric caeca and continue posteriorly in a more or less indefinite manner. Near the anterior part of the ileum they unite together to form a single tube which extends posteriorly along the latero-ventral side of the tract. The dorsal trunk, in the region between its connection with the fourth and sixth spiracles, gives off numerous branches to the gonads.

The single tube given to the alimentary tract from the second spiracle joins a large tracheal tube (VAL). This extends on the ventral surface from the tips of the caeca to the hind region of the ileum. Here it joins the common tube of the united dorsal and lateral tracheae. Posteriorly, each common tube is connected indirectly to the respective eighth spiracle, and ends in an air sac in the respective paraproct.

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EGYPTIAN BITING MIDGES OF THE GENUS *CULICOIDES* LATR.

[*Diptera: Chironomidae-Ceratopogonidae*]

(with 3 Text-Figures)

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This study is part of a survey carried out by the authors among the Egyptian villages. It concerns the biting midges of the genus *Culicoides* Latreille and is based on adults taken at light traps. In general, the location of the traps was close to water, banana plantations as well as clover and cotton fields, that might serve as breeding sites. These collections were done on the last week of October, 1959, at Shatanoof (Menofeia Province) near Cairo. The techniques followed were essentially the same as those described for the collection from Mitt-Yaish (NAGATY and MORSY, 1960). The three species of *Culicoides* recovered amongst the 89 samples collected were represented by *schultzei* Enderlein, *distinctipennis* Austen, *similis* C.I. and M.. *Culicoides schultzei* was the most abundant, followed by *distinctipennis* and *similis*.

Culicoides schultzei (46 females and 17 males) was collected nearly a small channel, *Culicoides distinctipennis* (13 females and 7 males) nearby a banana plantation and *Culicoides similis* (4 females and 2 males) nearby a cotton field by the side of a small channel.

Culicoides similis is a more or less small species, measuring about 1.2 to 1.3 mm. (female), while the male is slightly shorter. Its head is dark brown with the eyes separated in both sexes. Proboscis as well as the palpi brown, antennae rather pale brown. Thorax also brown and sometimes light brown. Nevertheless, the adornment of the mesonotum is not clear. Scutellum pale brown or yellowish brown with a dark brown median band. Post-scutellum dark brown. Halteres more or less

whitish in colour. Legs brown, each having a dark brown knee which is preceded and followed by a light band. However, the pale band is more or less indistinct. Another pale band is found on the distal half of the tibia.

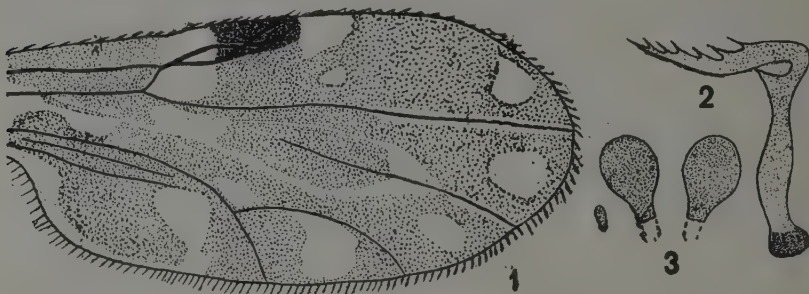


FIG. 1: Wing of female *Culicoides similis*. — FIG. 2: Parameres of same. — FIG. 3: Spermathecae of same.

The wing of the female (Fig. 1) measures about 1.1×0.45 mm. In general appearance, it is brown in colour with many ill-defined pale areas. However, the second radial cell is included in a dark brown area. The distribution of the pale areas is as follows: cell R_5 provided with 2 pale areas, one just beyond the end of the costa while the second lies beyond and below it, distal part with another pale area that does not touch the apical margin. Cell M_1 with only one area that also does not touch the apical margin. Cell M with one area that stops short before the apical margin. Mid-way of the vein M_2 included in an ill-defined pale area. Cubital cell with a large pale area that is bordered anteriorly by Cu_1 , while posteriorly it slightly touches the posterior wing margin. In front of the cubital bifurcation, lies a well defined triangular pale area. In the anal cell, there is an area which is enlarged anteriorly and narrowed posteriorly. This anal area is in communication with the small basal pale area which includes the wing base, by a pale strip that borders the postero-basal margin of the anal cell.

Radial median cross vein included in a large pale area, posterior of which there is an elongated pale area before the median bifurcation which is connected to the basal area by a narrow pale strip. Distal half of both veins M_1 and M_2 are bordered by narrow pale strips. Macrotrichia well represented and distributed all over the wing.

Male hypopygium with the 9th tergite narrowed posteriorly and sparsely clothed with moderate hairs. Posterior margin not notched, but bearing rather 2 small lateral finger-like processes, the apico-lateral processes 9th. sternite with a rather deep central excavation. Coxites short, broad and narrowed posteriorly. Dorsal roots as well as ventral roots of the coxites well developed. Stylets, each with the anterior third enlarged while the posterior two-thirds narrowed gradually.

Parameres (Fig. 2) stout, well developed admedian structures, stem of each carrying distally a knob, while the posterior edge is serrated. Number of serrations 7 in both branches (CARTER et AL (1920) stated that the number of serrations in each paramere varies from 6 to 9, while in all our materials they are constant). Aedoeagus more or less Y-shaped. The 2 limbs are highly chitinized, narrow, with their basal extremities slightly everted forming, in general shape, a broad low arch with a rounded apex over the excavation in the 9th. sternite. Terminal portion of the aedoeagus long, tapering and less highly chitinized. Membrane joining the aedoeagus to the 9th. segment devoid of spicules.

Two spermathecae of the female (Fig. 3) large, highly chitinized, ovoid to pyriform in shape, one of them slightly larger than the second and measuring about $50 \times 38 \mu$, while the second measures about $48 \times 36 \mu$. Duct of the spermathecae chitinized for about 11μ . The third spermatheca is reduced and more or less tube-like, measuring about 14μ long.

Culicoides similis was first collected and described by CARTER et AL (*loc. cit.*), from the Gold Coast, South Africa. Our materials only differ from that of CARTER et AL in that their material was shown to have two pale areas in the anal cell, while in ours the 2 areas fuse and form only one. This difference might have escaped the notice of CARTER et AL and in this case only examination of their material will clear this point. If the difference really exists as has been noted by us, then our material might represent an Egyptian variety.

Culicoides similis was reported in 1938 by CAUSEY, in Siam. In Egypt, it was already recorded by MACFIE (1943) from Moascar, Ismailia, stating that the thorax in a few of the specimens was quite light brown in colour. This character was very clear in only two of samples of our materials. However, MACFIE did not refer to the wing pattern or to the male hypopygium at all. In South Africa, specific description of this species was given by FIEDLER (1951).

A variety, *C. similis baghdadensis*, was recorded in Iraq by KHALAF (1957). His species differs from typical example of *similis* C.I. and M. in the following points: (a) mesonotal pattern not clear, (b) pale areas in the cell R_5 , M_1 , and M interrupted by the wing margin, (c) macrotrichia well distributed except in cell R and the basal part of cell M_2 , (d) the rudimentary spermatheca long and narrow and measuring about $24 \times 3 \mu$. CARTER et AL did not refer to this third spermatheca, while in our's it is present and measures about 14μ .

SUMMARY

Three species of *Culicoides*, viz. *schultzei*, *distinctipennis* and *similis* were collected and are recorded for the first time from the village of Shatanoof. *C. schultzei* is the most abundant species while *C. similis* is scarser. A detailed description of *C. similis* is also given in the present paper.

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BULLETIN
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1960



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السنة الثالثة والخمسون

العدد الرابع والأربعون

مجلة
الجمعية المصرية للعلوم الطبيعية



تأسست في أول أغسطس سنة ١٩٠٧

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